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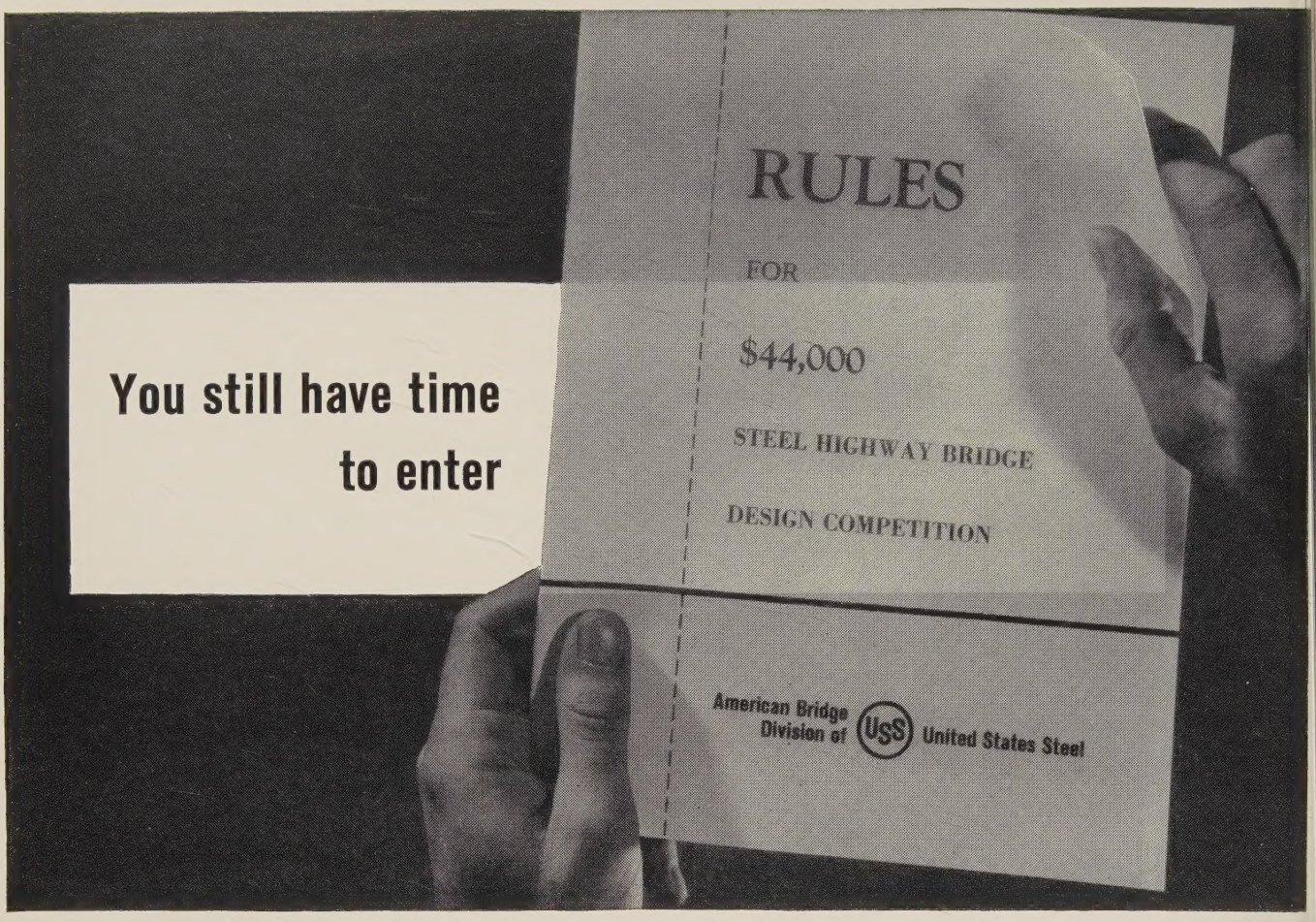

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THE ILLINOIS TECHNOGRAPH

Volume 74, Number 6 March, 1959

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Cover . . .

Brian Wittenkeller, the cover artist for this issue, has superimposed one of the major tools of modern industry on a background in which it is quite at home. This integrating device and many others will be discussed in the article on page 15.

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James Reeder joined Westinghouse in 1955—now working on jet aircraft power systems

At 26, James R. Reeder, a 1955 BSEE graduate of Vanderbilt University, is fast becoming an expert on aircraft electrical systems. Now the project engineer in charge of designing and developing control and protective equipment for the AC electrical system of North American's A3J-1 twin jet fighter, he previously designed transistorized protective equipment for the power system in the Boeing 707 Stratocruiser.

Most important, *Jim Reeder is doing exactly what he wants to be doing.* Upon completion of the Westinghouse Student Training Course, he was assigned to the Aircraft Equipment Department in Lima, Ohio. He has submitted 12 patent disclosures (which have resulted in awards totaling more than $800.00); and he has four U.S. patents pending. Active in the AIEE, he has completed more than half the work required for his MSEE at the University of Pittsburgh through the Westinghouse Graduate Study Program.

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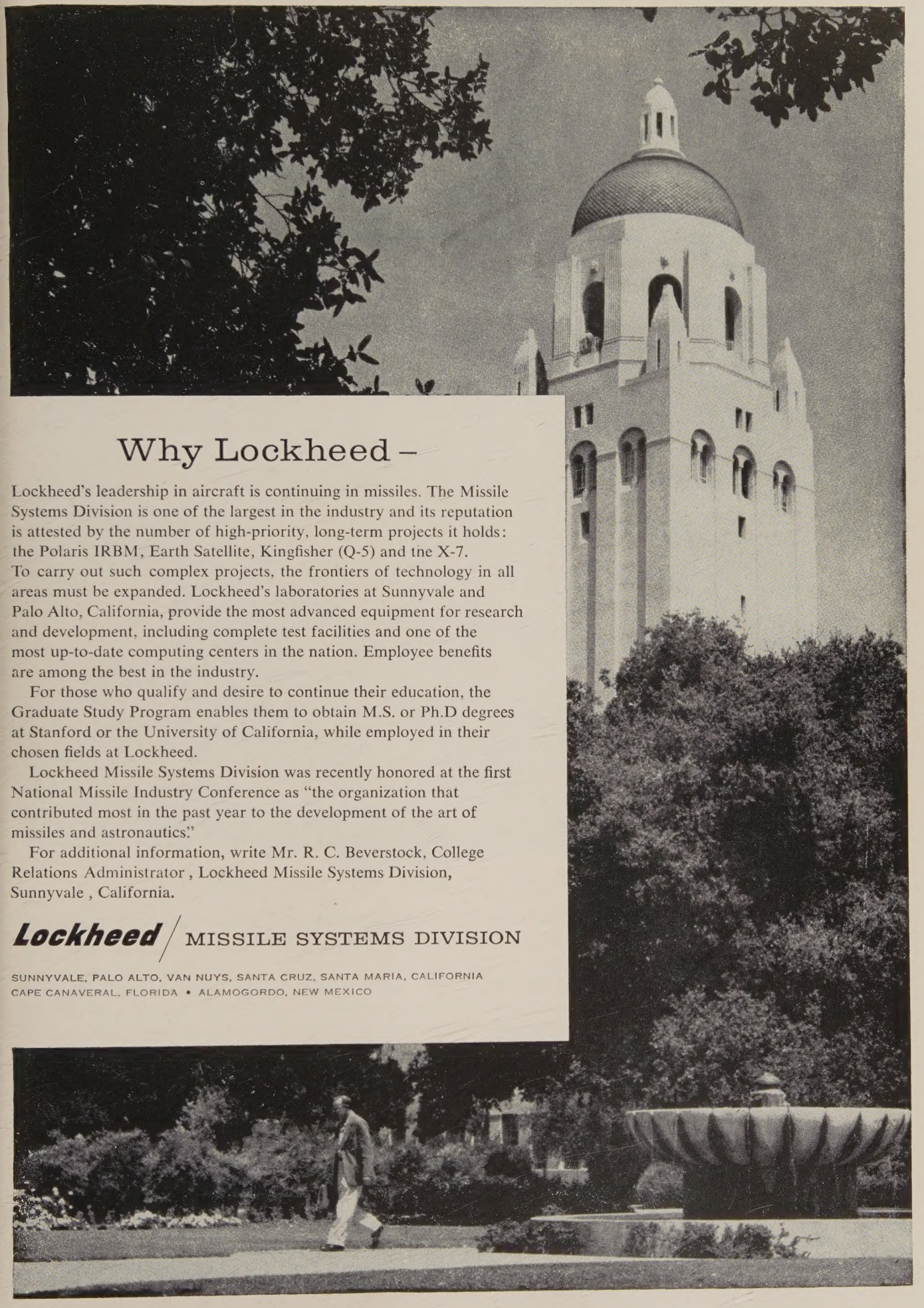

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Lockheed Missile Systems Division was recently honored at the first National Missile Industry Conference as "the organization that contributed most in the past year to the development of the art of missiles and astronautics."

For additional information, write Mr. R. C. Beverstock, College Relations Administrator , Lockheed Missile Systems Division, Sunnyvale , California.

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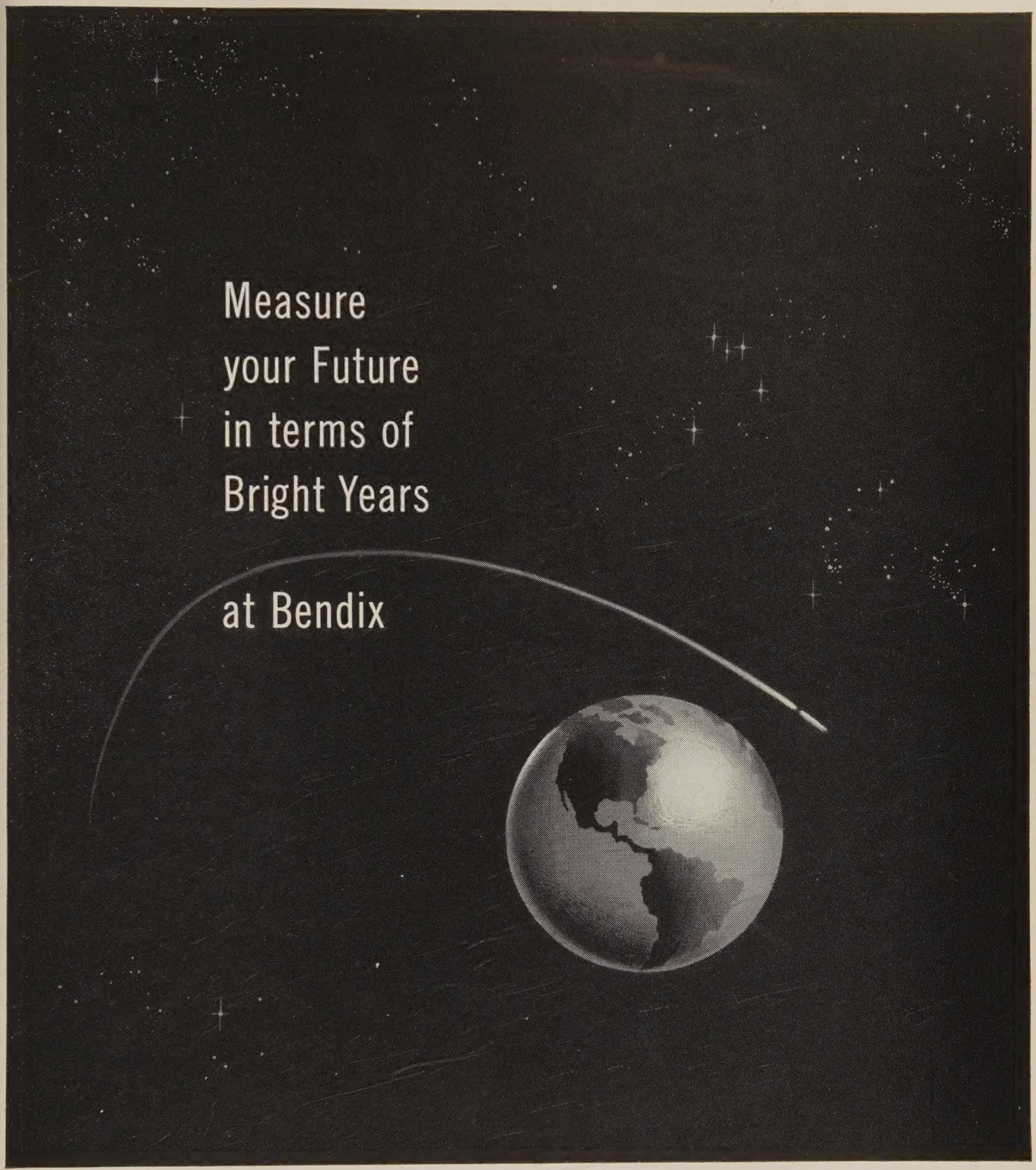

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MANY SCIENTIFIC SKILLS are needed to meet the research challenges of the petroleum industry. Shown above are (l. to r.): Kemp Bunting, mechanical engineer; Arthur Sisko, physical chemist; Thornton Traise, organic chemist; Wilbur Hayne, chemical engineer. They are members of the research team that developed Standard Oil's revolutionary new Supermil ASU greases. These amazing lubricants are the first to deliver normal performance at *both* extremely high and low temperatures.

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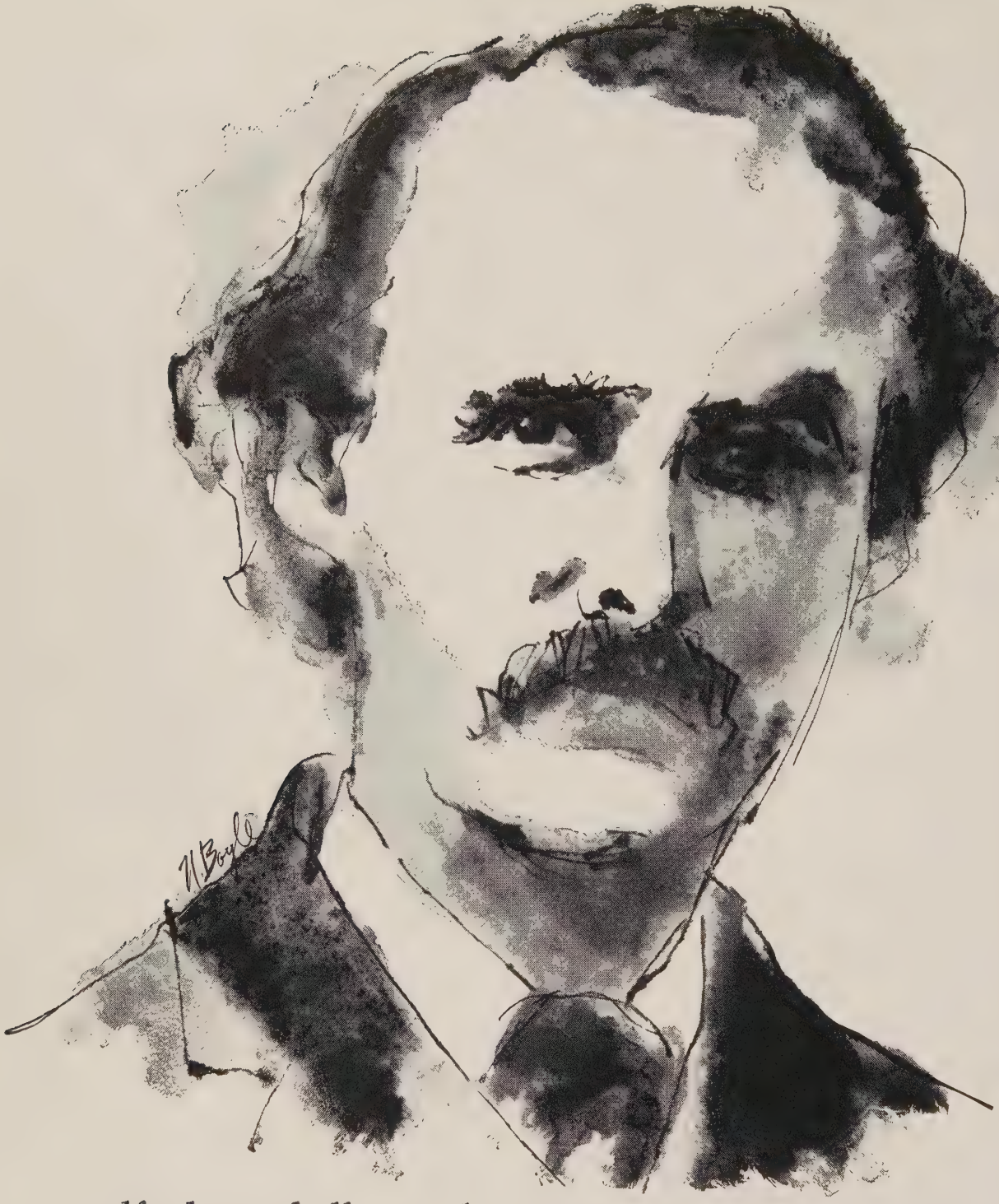

Alfred Marshall...on the tendencies of human action

"The laws of economics are to be compared with the laws of the tides, rather than with the simple and exact law of gravitation. For the actions of men are so various and uncertain, that the best statement of tendencies, which we can make in a science of human conduct, must needs be inexact and faulty. This might be urged as a reason against making any statements at all on the subject; but that would be almost to abandon life. Life is human conduct, and the thoughts and emotions that grow up around it. By the fundamental impulses of our nature we all—high and low, learned and unlearned—are in our several degrees constantly striving to understand the courses of human action, and to shape them for our purposes, whether selfish or unselfish, whether noble or ignoble. And since we *must* form to ourselves some notions of the tendencies of human action, our choice is between forming those notions carelessly and forming them carefully. The harder the task, the greater the need for steady patient inquiry; for turning to account the experience, that has been reaped by the more advanced physical sciences; and for framing as best we can well thought-out estimates, or provisional laws, of the tendencies of human action."

—*Principles of Economics*, 1892

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TOUCHE'?

This page usually contains something which I hopefully think of as an editorial and is intended to give you insight and provoke much thought. But the thoughts that it provokes for me are just as fruitful if not more so.

In the first two issues I might have seemed unduly critical of the engineer per se. In fact I was taking advantage of a new found outlet for many of my feelings. But after receiving no comment pro or con on these endeavors I decided either I had hit the nail on the head or else the editor's page was being used for scratch paper.

Granted my third editorial was just a trick to get you, the reader, to look at the help wanted ad asking for staff members for this, your magazine.

I can not promise that my editorials in the future will give you satisfaction always, if ever. But I will keep nagging and using tricks if need be to achieve the purpose of this page. And that purpose is to provoke thought and get action. I would like nothing better than to have someone stop me and ask what the hell I mean by associating the word engineer with such traits as lethargy or apathy. Also there is always room in this magazine for any reply you might have to things I have said.

WDP

THE ILLINOIS TROUGH

A Radio Telescope

by James H. Griffith

Prepared for the writing course English-General Engineering 304 by James H. Griffith. The author wishes to thank the following classmates who chose to help make valuable contributions to his article: Glen Bellows, A. E. Lipka, Robert Anderson, Carl Meskimen, Robert Bailey, and Paul McCarron.

The University of Illinois will soon obtain another tool for greatly increasing the distance that man can "see" into space. As part of a basic research program, the University Departments of Astronomy and Electrical Engineering are co-operating in the design of a giant new radio telescope. It will be used under the direction of Professor George C. McVittie, Head of the Department of Astronomy. Radio telescopes are providing important discoveries in the investigation of what is the universe. Unlike optical astronomy radio astronomy is unaffected by clouds, rain, smoke or sunlight.

The Office of Naval Research—interested in "big dish" antenna design problems—has given the University a $233,000 grant. The University has purchased the land and will operate the installation after completion.

The Trough's Creators

The radio telescope is being developed by Dr. George W. Swenson, Jr., University of Illinois professor of astronomy and electrical engineering, who is also in charge of its construction. During its development he has consulted leading astronomers in Australia, England, France, and Russia. Dr. Raymond A. Davidson, assistant professor of electrical engineering, is responsible for the receiver design and Dr. Yuen Lo, research assistant professor of electrical engineering, is designing the antenna feed system.

Presently the project staff consists of Drs. Swenson, Davidson, and Lo. After completion of the construction and installation of the equipment, there will be one or two full-time members of the staff responsible for maintenance of equipment. Routine operation of the radio telescope will be done by graduate assistants.

World's Largest Reflecting Telescope

The Illinois TROUGH, as the telescope is becoming affectionately known, utilizes a parabolic cylinder surface as an antenna reflector. Total area is 400 x 600 feet; however, a surface of only 160,000 square feet will be used at any given time during operation. The Illinois "dish" has more than three times the area of the great Jodrell Bank antenna in England. The receiving antenna system consists of four hundred to five hundred individual elements. These will probably be ten-to-twelve-inch equiangular conical spirals specially developed by the University of Illinois Antenna Laboratory.

The individual elements will be su ported at the focal point of the par bola by a bridge supported by towe over 150 feet high (Figure 1). Ea spiral element is connected to the r ceiver by a primary feed system whi makes possible the electrical phasing the signals received.

How The Telescope Is Aimed

If two antennas (Figure 2) are co nected, the radio waves A reach t elements in phase and reinforce eac other. Signal B reaches the right a tenna first and then the left. When t extra distance travelled is one-half t wavelength, the signals at the two el ments cancel. If the signal has a di placement equal to one wavelengt however, (signal C), the signals rei force each other.

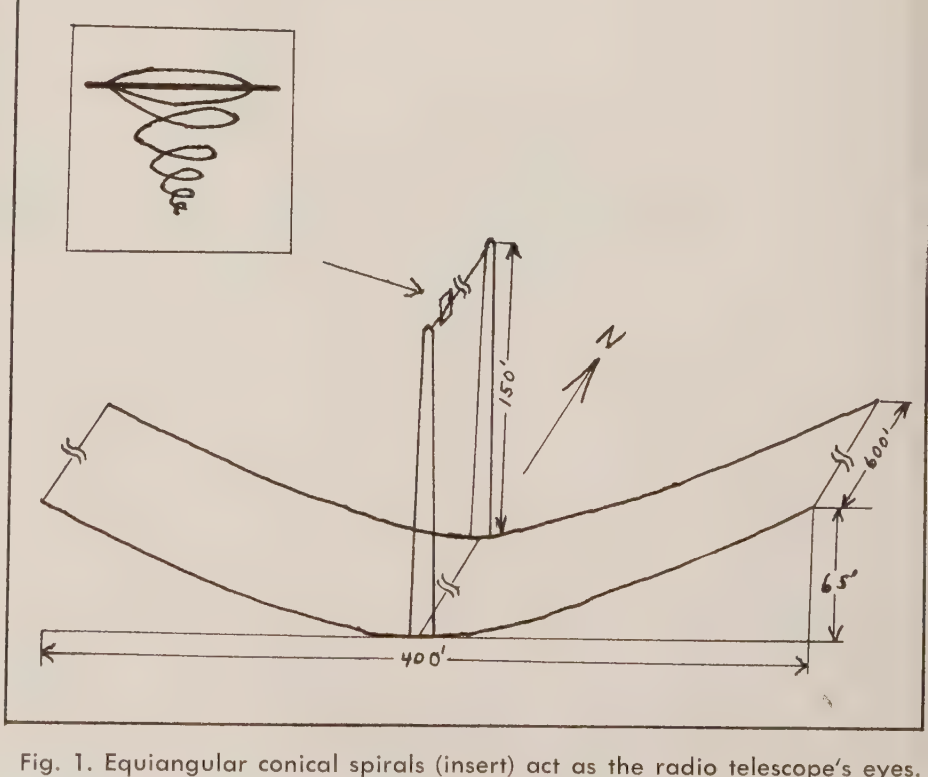

Fig. 1. Equiangular conical spirals (insert) act as the radio telescope's eyes. They receive radio waves reflected from the large parabolic surface which concentrates them at the focal point.

The radiation pattern from a two-component system has lobes which indicate the directions of maximum sensitivity (Figure 3). By increasing the number of elements and placing them a half wavelength or less apart, a pattern can be obtained in which the side lobes are suppressed, and the center one is predominant (Figure 4).

The length of the antenna lead from the individual elements to the receiver will be varied by a method called electrical phasing. This unique application will allow the telescope to be "tilted" from 30°N of the zenith to 30°S. The size of the reflector and receiving elements provides a "resolution" — described as beam width at half power— of 25 minutes of arc. To duplicate the resolution of the 200-inch Palomar telescope at a wavelength of one meter would require a radio telescope as large as the earth's diameter.

Signals From Space

Though ordinary stars are weak radiators, groups of stars and galaxies provide detectable signals. The Illinois antenna will be given a novel design

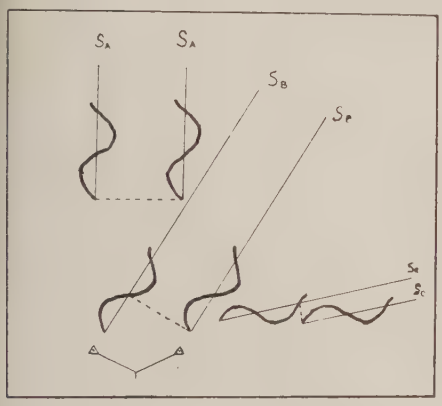

Fig. 2. When two antennas (1 and 2) are connected, radio signals such as from sources S_a and S_c are detected if the same portion of the wave cycle reaches both elements simultaneously or are "in phase." If a signal comes from a source S_b where the wave arrives out of phase, the signals cancel each other and are not detected.

in order to provide a very large receiving area capable of collecting radiation from much weaker sources while remaining economically and structurally feasible.

As early as 1955, radio astronomers had reported picking up radio signals from 1,936 heavenly bodies. One of the strongest known radiation bodies is Cygnus A, a pair of galaxies in collision 200 million light years away. Cygnus A emits enough radio energy in a single second to supply all the earth's heat and power for the next trillion years. Visually, however, Cygnus A is so faint that long exposures with the largest optical telescope are required for detection.

Cygnus A is one of the systems which investigators have found do not follow the radiation pattern demonstrated by familiar radiating bodies. These systems radiate higher power levels at long wavelengths than at short wavelengths. This phenomenon cannot be explained by the conventional radiation process produced by the random motion of particles as in the filaments of electric lamps which radiate more strongly at shorter wavelengths. This latter process, however, probably accounts for the steady flow of radio waves from the quiet sun.

Interaction of Cosmic Forces

The radio signals seem to be associated with violently moving gases. The

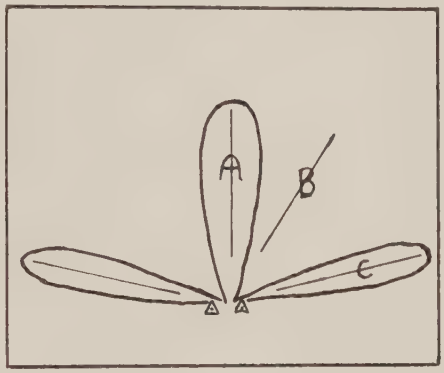

Fig. 3. The radiation lobes indicate directional sensitivity obtained with a two-component antenna system. Signals A and C are received strongly, while signal B is not detected.

more violent the motion, the stronger the signals. These radio waves are thought to be the result of rapid electronic vibrations in the gases themselves (10^7 to 2×10^{11}/second).

One partial explanation is a process known as plasma oscillation—associated with thin clouds of electrons spread over vast regions of space. The electron clouds are alternately compressed to a small volume by some cosmic force until repulsive electronic forces make the particles fly apart. Once they pass their equilibrium position, repulsive electronic forces from the outer shell of the electron cloud and other cosmic forces again compress the expanding particle mass to the more concentrated volume.

Another partial answer has been discovered during recent work with high-energy particles. Particles ejected from a synchrotron at speeds near the speed of light were found to glow with a weird intense light. It is throught possible that interstellar magnets are formed by diffuse gas clouds which in effect produce a stellar synchrotron.

Big "Dish" Reflectors

Even the signals from such violently moving sources reach the earth with a very low intensity. In order to obtain a higher intensity by concentrating the radio waves to a single point, all radio telescopes must utilize a larger reflecting surface. The Illinois antenna makes use of a relatively simple but efficient method for providing such a surface.

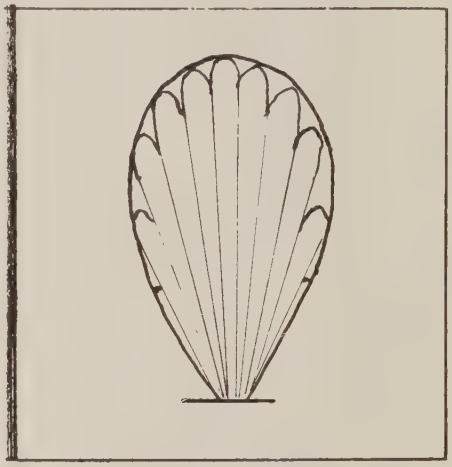

Fig. 4. When many antenna elements are used the side lobes present in two-component systems are suppressed. A predominant center lobe is obtained. The TROUGH'S unique design will provide a beam width of 25 minutes of arc.

The antenna reflector (Figure 5) consists of an electrically homogeneous surface formed by a layer of hot-dipped, one-to-two-inch steel mesh screening.

The antenna elements will be suspended below an enclosed box-channel catwalk four feet wide and ten feet high. The catwalk is strung between towers over 150 feet high. The main building will be 400 feet from the towers. The biggest question at this time is how to compensate for temperature contraction and expansion in the tower, antenna, and antenna feed system.

"Seeing" the Signal

The antenna elements will be connected through the antenna feed system to the indicating and recording instruments. The signal received will first pass through an RF (radio frequency) amplifier to amplify the very faint signal, and will then pass into a frequency converter. The converter will reduce the frequency of the amplified signal from about 600 to about 50 megacycles. This is done for the simple reason that lower frequencies are easier to amplify. Then the signal is amplified again in an IF (intermediate frequency) amplifier. It then goes through another frequency converter, and finally

(Continued on Page 32)

There's much more to it than just the size of the FISH and the size of the POND

O

We've been told that an engineering graduate is frequently attracted to companies our size because of his understandable human desire to be "a big fish in a little pond".

While it is true that (numerically speaking) our employee team is small compared to some, we encounter great difficulty in trying to think of Sikorsky Aircraft as a "little pond". Our contributions to the field of rotary-winged aircraft have not been small, nor can our field be considered limited or professionally confining. Quite the contrary. Sikorsky Aircraft is the company which *pioneered* the modern helicopter; and our field today is recognized as one of the broadest and most challenging in the entire aircraft industry.

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COMPUTERS THROUGH THE AGES

by Kermit W. Heid

Computers, although generally believed to be a modern day development, are actually as old as mankind. When you watch a small child counting on his fingers you are witnessing the operation of the oldest (and most often used) digital computer. The belief that computers are recent inventions stems from the fact that the advent of the electronics, atomic, and space ages, all occurring within the last twenty or thirty years, introduced problems so complex that, without the use of computers, thousands of man-hours would be required to find the solutions. Hence the development and use of computers increased enormously in this period.

There are two distinct branches in the computer family. One branch, the digital computers, are descendants of the abacus which was used in the Tigris-Euphrates Valley as early as 5000 years ago. This type of computer may be called "discrete" because it recognizes only discrete values, 0, 1, 2, etc. The second branch of the computer family, the analog computers, began with the straightedge-and-compass construction of the ancient surveyors. The earliest known analog computation occurred in Babylonia about 3800 B. C., in the form of surveying and map making for taxation purposes.

In 1614 John Napier invented logarithms and with the help of John Briggs converted them to the base 10 in 1615. This led to the development of another type of analog computer, the slide rule. Edmund Gunter used Napier's logarithms to create a slide rule with no moving parts, in 1620. In 1632 William Oughtred invented the astrolabe, which was the forerunner of the modern day slide rule.

The next analog computer to appear on the scene was the nomogram, a diagram representing some mathematical relationship which can be expressed analytically by an equation. This device was first used by Rene Descartes, in the form of graphs, to find the real roots of algebraic equations. Margetts extended the art of nomography to three variables when he published a set of longitude and time tables for the guidance of mariners in 1791. Margetts drew a family of curves in the xy plane, one curve for each value of z. This was a rather tedious job since it was difficult to draw some of the curves accurately. This problem was solved in 1842 when Leon Lalanne suggested a method of coordinate transformation to change the curves into straight lines. It remained, however, for Maurice D'Ocagne to organize the subject in much the form it is found in present texts to give it the name "nomography."

Up to now, we have discussed only one of the two main classes of analog devices, the function computer. The other main class, the integrating computer, appeared later than the function computer. It is possible the development of calculus accelerated the discovery of integrating computers. As implied by the name integrating computers can be used to find $\int f(x)\,dx$ or $\int y\,dx$ whereas function computers such as the slide rule are used to find ax, xy or x^a.

One of the earliest integrating computers was the planimeter, invented about 1815 by J. H. Herman, a Bavarian engineer. The planimeter measured the area bounded by a closed curve plotted on a piece of paper. In 1854 Jakob Asmler popularized the planimeter with the invention of his polar planimeter. It is interetsing to note that his design is practically unaltered in the modern day polar planimeter such as the one shown in Fig. 1.

Another computer, the integraph, appeared on the scene during this period. Abdank Abakanovicz in 1878 and C. V. Boys in 1882, working independently, invented this machine. This instrument could draw the integral of an arbitrary function when the function was plotted on paper to a proper scale. By manipulation of the integral curve and successive approximations one can solve certain classes of differential equations with an integraph.

James Clerk Maxwell proposed another type of planimeter in 1855. Maxwell's planimeter, using two equal spheres, did away with the disadvantage of sliding an integrating wheel axially. Although this idea was never reduced to practice because of its elaborateness, it stimulated another mathematician, James Thomson, to simplify the mechanism and develop the ball-and-disk integrator, shown in Fig. 2. Although Lord Kelvin, Thomson's brother, used the integrator in his "Harmonic Analyzer," full-scale use of the ball-and-disk integrator did not occur until the early 1900's because of its low torque output. The first naval gun-fire computer using the ball-and-disk integrator was developed in World War I after Hannibal Ford increased the integrator's torque output.

(Continued on Next Page)

Fig. 1. A modern planimeter

—Photo by Ray Dahman

The watt-hour meter, another integrating device, appeared late in the 1800's. The first meter, invented by Edison, used the principle of electrolysis. The amount of energy a customer consumed was determined periodically by weighing the anode of the meter. The increase in weight, caused by the depositing of metal during the electrolysis process, was proportional to the current through the anode and hence

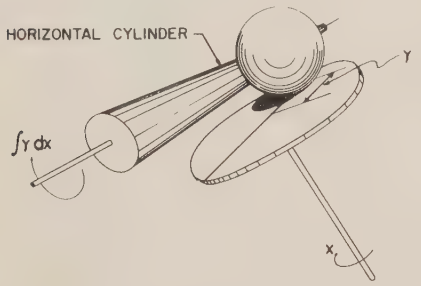


Fig. 2. Ball-and-disk Integrator.

the power consumed. The electromechanical DC meter followed shortly and then, as the nation converted from DC to AC the AC watt-hour meter was developed. The latter is basically a small motor whose rotational velocity is proportional to the power consumed. The energy supplied in any time interval is therefore proportional to the angular displacement during the interval. The dial readings are determined by the angular displacement and the proportionality constant.

With the exception Kelvin's Harmonic Analyzer and the naval gun-fire computer, we have discussed only unit or single devices. It was not until the 1920's that the computer systems really came into being.

One of the earliest computer systems was the continuous integraph, developed by Dr. Vannevar Bush, F. D. Gage and H. R. Stewart at Massachusetts Institute of Technology in the middle 1920's. Utilizing the watt-hour meter as an integrating device, this machine could perform the integration of the product of two functions or solve for the unknown, $\varphi(x)$, in an equation of the form $\varphi(x) = \int^x f(x)\varphi(x)dx$ where $f(x)$ was known.

Although only one integration was involved in this first machine, it's obvious utility led to more development and in 1930 a machine using 6 integrating, units was built. A relay servomechanism, used in the original machine to reduce drag loads on the meter disk, was replaced by the mechanical torque amplifier based on the principle of the capstan.

Bush continued working in this field and, in 1942, one of the most elaborate differential analyzers in existence was placed into operation. It had 18 ball-and-disk integrators with a projected capacity of 30. The ball-and-disk integrators replaced the watt-hour meters to give an additional decimal point of accuracy. This machine used electrical coupling between the mechanical analyzers. The coupling was controlled with the help of switching techniques similar to those used in telephone practice. This allowed programming on punched paper tape all the connections between integrators, gear boxes, inputs and outputs. This analyzer was used in the solution of ballistics problems in World War II.

Another computer system, the network analyzer, first appeared about the time Bush developed his original differ-

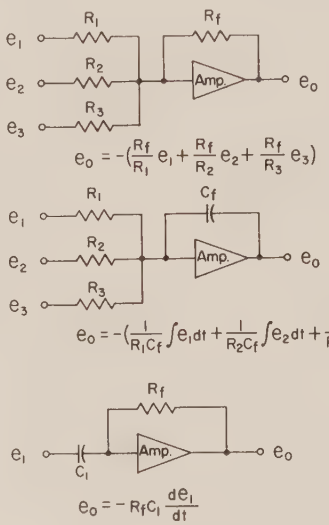


Fig. 3 External Connections Showing Possible Uses of Operational Amplifier.

ential analyzer. This machine, used to simulate power networks, appeared initially in 1925 as a DC Network Analyzer. Because it is a resistive analog, it is limited to steady state problems involving purely resistive or purely reactive networks. The AC Network Analyzer, introduced in 1929, was a much more versatile machine. It included three types of linear impedances which allowed it to simulate AC power networks and display both magnitude and phase of the solution.

The next step forward in the development of analog computers was the electronic analog computer. The basic unit of this machine is the operational amplifier whose development during World War II is generally credited to Lovell and Parkinson. However, the unpublished papers of G. A. Philbrick reveal he used such a device in computing circuits for the solution of servomechanism problems as early as 1938.

The operational amplifier is a stabilized feedback amplifier of standard design which, by appropriate changes in the feedback and input circuits, can be used as an integrator, differentiator, multiplier, summer or sign changer. The symbolic representation of the amplifier, showing appropriate circuits for the various uses is shown in Fig. 3.

Between World War II and the present day computers developed very rapidly and electronic analog computers kept pace with the rest of the computer family. The complexity of these computer systems range from the 10-15 amplifier desk top type, through the 20-40 amplifier installation such as the one at the University of Illinois shown in Fig. 4, to the 2500 or more amplifier installation of the Convair Aircraft Company at Fort Worth, Texas. One can use the analog computer to solve linear and non-linear differential equations as well as algebraic equations. The order and number of simultaneous equations these computers will solve is limited only by the number of operational amplifiers and auxiliary equipment, such as function generators, multipliers, resolvers, etc., available.

At present one can classify the electronic analog computers under three main headings. First is the general purpose machine which is applicable to any problem which can be stated in mathematical terms. The second group is the special purpose machines. Included in this group is the type which have cer-

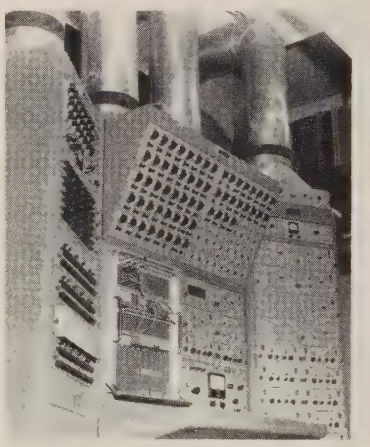
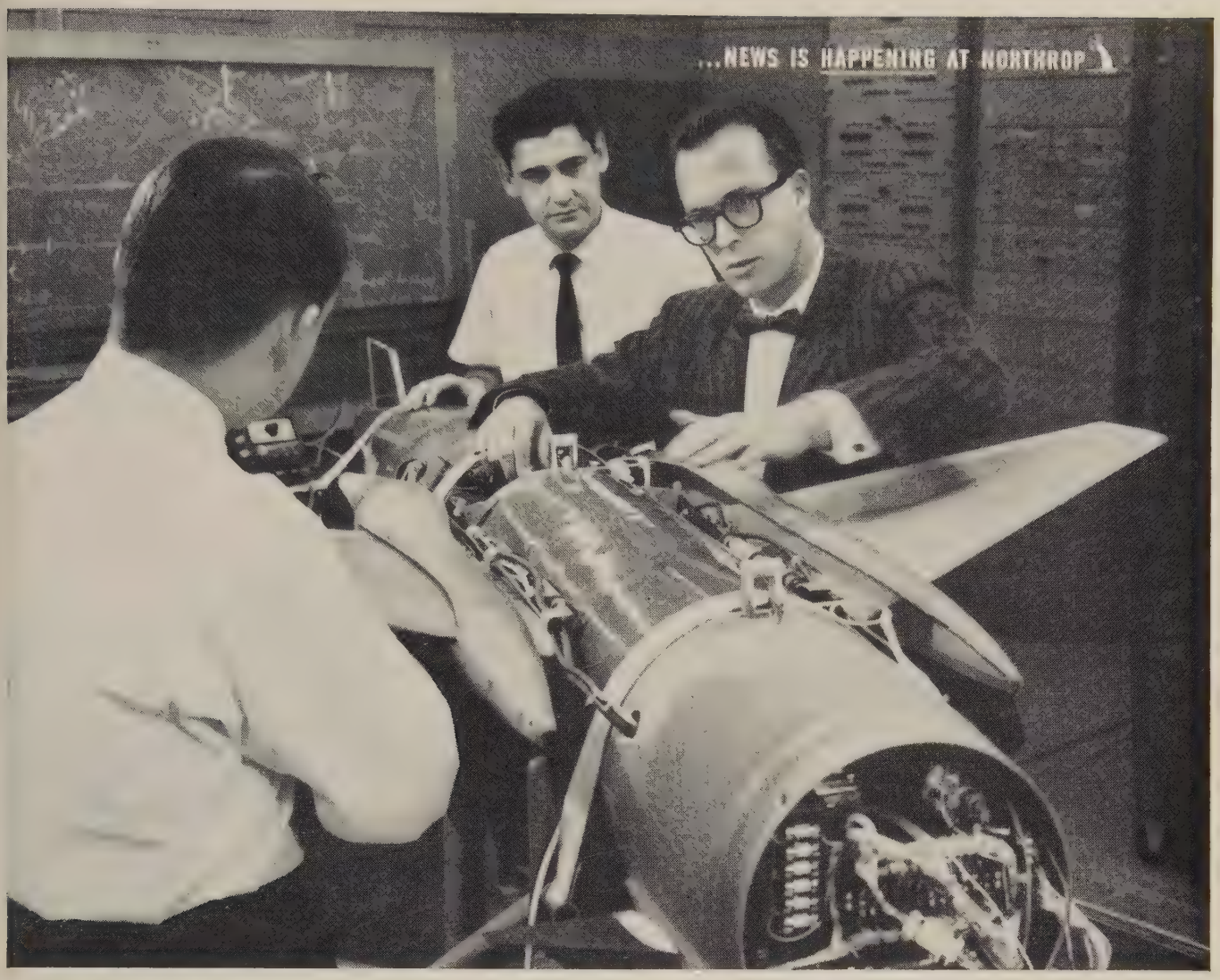


Fig. 4. A 20-40 amplifier
(Installation Photo by Dave Yates)

tain operations permanently installed in the problem board. This type of machine has been used to simulate the flight characteristics of newly designed aircraft before the prototype is built. The last group is the hybrid machine, a combination of the electronic and mechanical computer. This type has been used in some of the military radar systems.

This is the history of the electronic analog computer. It was not an overnight development, so to speak, but one which took thousands of years. With electronic computers fast replacing the slide-rule as the engineer's basic tool, it is important that he should know the computer's past history so that he may play a part in its future.



Engineer Larry Klivans reviews the results of a computer-simulated ground checkout of Radioplane Division's near-sonic RP-76 rocket-powered target drone. Formerly at Norair Division, Larry came to Radioplane in 1955. At 31, he is Manager of the Division's 140-man Electronic Support Group, is working toward his doctorate at UCLA.

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A FURTHER LOOK AT STEREO

by J. C. Stevenson

Editor's Note: This is a follow up to our first article in the January issue on stereo recording.

Until the recent stereo boom, the record buyer was forced to "enjoy" music that lacked perspective: depth, spread, and directionality; the orchestra's spatial arrangement was funneled into speakers with a total area of 12 to 154 sq. in. But with the advent of commercial, compatible stereophonic recordings, the record fan is no longer confined to a one-dimensional world of sound, for orchestras have been partially restored their spatial characteristic; with two sound channels, relative positions of various instruments become distinguishable — both in breadth and depth. Strangely enough, this new world of sound is not really new at all, for stereophonic sound reproduction is, in fact, an old concept dating back to the nineteenth century.

Stereo Lies Dormant

The long history of stereophony is evidenced by the fact that work on spatial sound reproduction was conducted in conjunction with the 1881 Paris Electrical Exposition. In 1933 a British patent was issued to A. D. Blumlein for a single-groove stereo system, and Rafuse and Keller of Bell Telephone Laboratories patented a vertical-lateral stereo cutter in 1938. Figures 1 and 2 show some of the equipment used by Bell Labs during the 1930's in their stereo research program. Though the fact is not generally known, Walt Disney's *Fantasia* (1941) was made with a three-channel sound track. Then why, with a history just under eighty years, has stereo been so long in coming to the public?

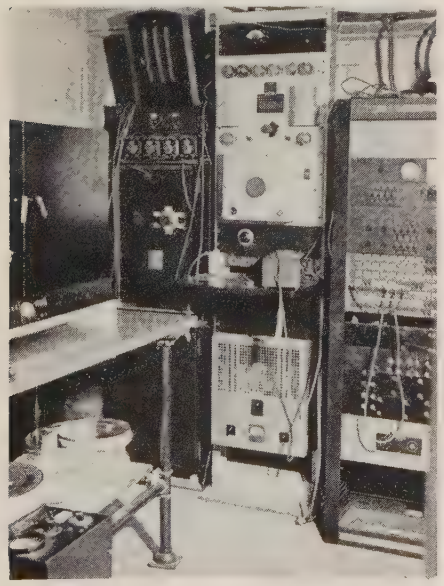

Fig. 1. Stereophonic recording room—Philadelphia, 1939. (Courtesy Bell Telephone Labs)

Concentration on defense work notwithstanding, the primary reason for stereo's slow evolution is found in those economic terms *supply* and *demand*. Before 1957, the complexity of stereo recording methods and playback equipment made mass production so nearly impossible that stereo would have been too expensive for wide public acceptance. All in all, the stereo picture held little promise for commercial appeal, and as a result the record and equipment manufacturers were more concerned with improving the monaural (monophonic) disc and its playback systems.

Eventually, however, improvements in monaural reproduction reached a peak with the development of LP records, with the extension of frequency content beyond the ear's limits (normally 30-15,000 cps), and the virtual elimination of distortions. These improvement, plus the disc jockeys, helped make the audio industry a multi-million-dollar-per-year business.

With the public spending millions for records and equipment, small independent recording companies blossomed over night, and their incomes rose with the increasing popularity of records. But then sales started to lag. The big companies seemed content to rest on their monophonic bank accounts for a time, whereas the smaller firms were ready to pounce upon any potential money-making opportunity that came along. One came in 1957: motivated by British Decca's development of a single-groove stereo record, the Westrex Corporation, New York, gave birth to the 45-45 StereoDisk. Shortly after demonstrating their system at the 1957 New York High Fidelity Show, Westrex unintentially provided a catalyst for the stereo boom.

Adding the Catalyst

The catalyst was a master stereo disc cut for a small recording company—Audio Fidelity. At Audio Fidelity's request, Westrex made a stereo master from Audio Fidelity prerecorded tapes. Supposedly, this master was to be used for experimental purposes only, and in an effort to make certain of this, Westrex "gimmicked" the master to make it—so they believed—commercially useless. Once in the hands of Audio Fidelity, however, commercial copies were made and distributed to equipment manufacturers for tests. Unlike some of our Vanguard firings, the stereo missile was successfully, though perhaps unwisely, launched.

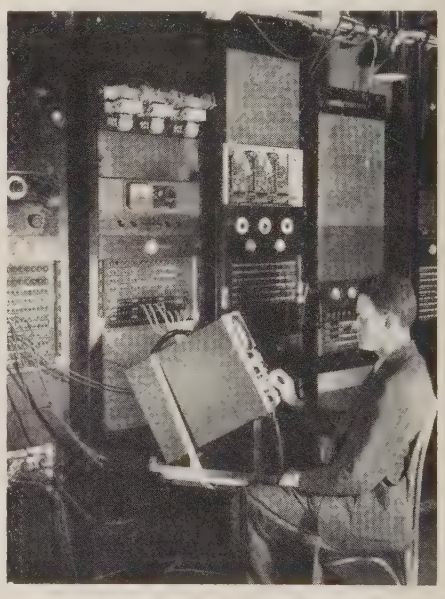

Fig. 2. View of stereophonic amplifiers and comparison equipment used by Bell Labs during the 1930's. (Courtesy Bell Telephone Labs)

And how the missile has traveled since 1957! After Audio Fidelity's scoop in issuing the first stereo record, large and small companies alike could not afford to hold back. Like the proverbial snowball, the stereo craze grew and grew within the industry. Many stereo systems, such as British Decca's vertical-lateral (V-L), Jerry Minter's F-M Multiplex (MSD), and Dr.

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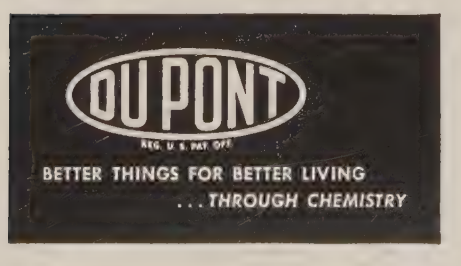

Technocutie . . .

(Photos by Dave Yates)

SALLY TURNER

The pretty Miss on these pages is Sally Turner, a junior in LAS. Her home on campus is Alpha Delta Pi. Originally she hails from Toulon, Illinois, a small but very lucky town we would say.

Among her interests are singing, playing bridge, and water skiing. During the spring you will find her at Lake of the Woods soaking up the sun in her spare time.

Her likes include music by Jackie Gleason, chocolate ice cream, and the color blue. On the domestic side she enjoys sewing and cooking.

Sally is twenty years old, has light brown hair and blue eyes. She is 5'-6" tall and weighs 120 pounds.

(Continued from Page 18)

Peter Goldmark's modified 45-45 (CBS Stereo Disc) systems came out of the laboratories, but remembering the 45-33 1/3 rpm fiasco, the industry jelled rapidly to adopt the Westrex 45-45 StereoDisk as the standard.

Adoption of the Westrex method resulted from a combination of two factors—timing and technical considerations. When the stereo furor began in 1957, there were essentially two stereo recording systems available for industrial consideration—the V-L and 45-45. Of the two, the 45-45 had several distinct advantages: 1) rumble (turntable vibration) is equally distributed between the two channels; 2) limitation on groove depth for vertical components is less severe; and 3) because the system is symmetrical, design of recording and playback equipment is less complicated, and balancing the two playback channels is simpler. Thus, the 45-45 StereoDisk became *the* stereo record.

Binaural Hearing and Stereo Reproduction

The 45-45 disc—or any stereophonic system—restores the orchestra's spatial arrangement by endowing sound with one or more of three characteristics that enable us to detect the location of a sound source: time, intensity, and phase differences.

To illustrate these differences, assume that you are standing on a street corner, and an ambulance — siren screaming—approaches from your right. Your brain immediately tells you that the ambulance is to your right because the sound reaches your right ear before reaching your left; there is a time difference in sound arrival at your ears.

Furthermore, there will be an intensity difference: sound waves dissipate power when traveling through air. Because the sound travels over a shorter path in reaching your right ear, sound intensity at the right ear will exceed that at the left, and once again your brain tells you the ambulance is to your right. Intensity difference is illustrated in Figure 3, which shows the relative intensity received by both ears when a sound source is moved clockwise from directly in front to directly behind a listener.

In addition to time and intensity differences, there is likely to be a phase difference. We are familiar with the fact that sound waves propagate through air as compressions and rarefactions (decompressions) of the air particles. When one ear receives a compression, the ear drum moves in, and when the other ear receives a rarefaction, the ear drum moves out. This phase difference produces a push-pull

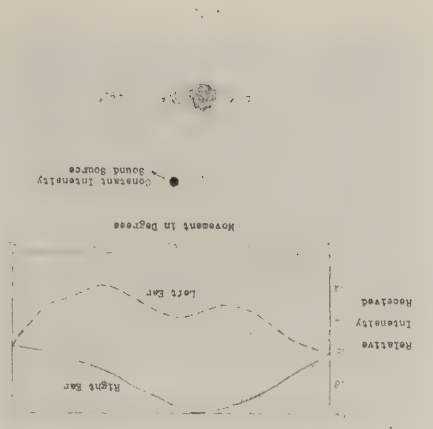

Fig. 3. Diagram showing the relative intensity of sound received by both ears when a constant intensity sound source is moved clockwise around a listener's right side. The two curves would be reversed if the source were on the listener's left.

action. The pushing action affects your auditory system differently from a pulling action, and your brain translates the difference in helping you determine that the ambulance is to your right.

By translating time, intensity, and phase differences—either singly or aggregately—your auditory system enables you to follow the ambulance's progress as it approaches, passes, and moves away to your left. This is binaural hearing.

The three different characteristics of sound also exist when you listen to a live concert performance: your brain informs you that the violins are on the left, the brasses are in the center, and the lower-register strings are on the right. Therefore, a stereo record and its playback equipment must produce the illusion of a live performance by keeping the various instruments in their proper perspective.

The 45-45 StereoDisk

Adding perspective to a recording requires at least two sound channels. A two-channel basic recording layout and its playback counterpart are shown in Figure 4.

Briefly, the theory behind these layouts is that the left side of the orchestra will predominate in the left channel, the right side will predominate in the right channel, and the center section will feed both channels equally to form an *apparent* third channel. In playback, the left - right relationship holds, and because the center sound has equal strength in both channels, the speaker outputs combine to form an apparent middle speaker or channel. We see then that a simulated three-channel stereo system is obtained by using only two playback and recording channels.

In the 45-45 system, both recording channels are cut into a single groove. As shown in Figure 5, one channel is cut into one side of the groove at a 45° angle to the record's surface, and the other is cut into the opposite side of the groove at a 45° angle to the surface. A bottom view and a simplified end section of the Westrex 3B recording head used for cutting 45-45 stereo discs are seen in Figure 6, and Figure 7 shows a microphotograph of the 45-45 grooves which contain stereo information.

In Figure 7, groove-width variations correspond to lateral components of the signal, and vertical components appear as variations in shading. Readily observed is the fact that each channel has

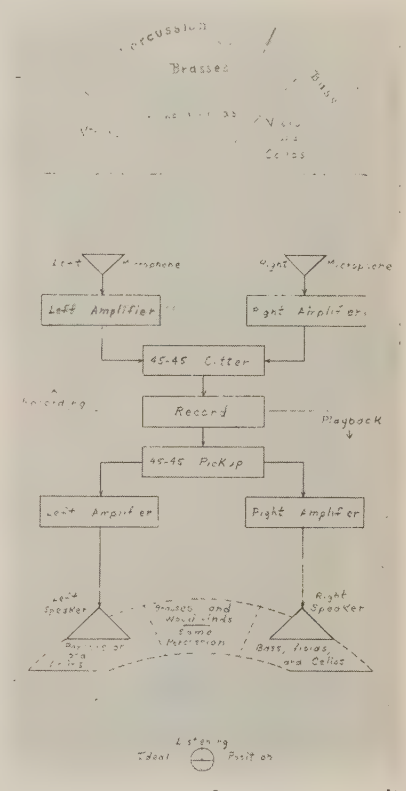

Fig. 4. Diagram of stereo recording and playback system.

both vertical and lateral components, and this makes the Westrex method *theoretically* compatible with existing monaural systems.

The Compatibility Bugaboo

Compatibility is a two-sided picture: monophonic records should be playable on stereo equipment, and conversely, stereo records should be playable on monophonic equipment. The latter is not, however, normally possible in the case of 45-45 discs. As shown in Figure 8, standard LP's are cut laterally (information is contained in transverse variations), and consequently, the stylus in a standard pickup is designed to move laterally. If used to play 45-45 records, the cartridge will combine the

(Continued on Page 26)

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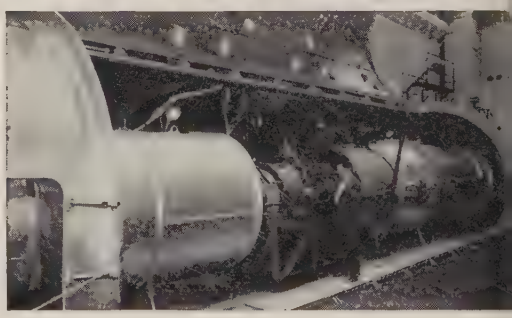

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lateral components of both channels to produce a monaural program. But unless the pickup has sufficient vertical compliance (freedom to move vertically), the 45-45 groove will be literally gouged to pieces. This vertical compliance requirement is the hitch in *practical* compatibility, for most standard pick-

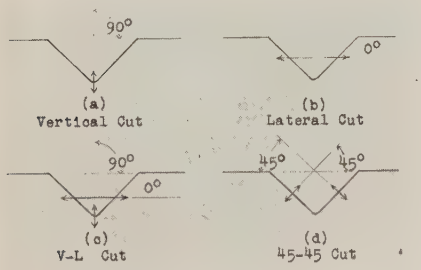


Fig. 5. Groove cross sections showing angular characteristics of monaural (a & b) and stereo (c & d) groove structures.

ups DO NOT have adequate vertical compliance.

Thus, where true compatibility is concerned, we see that standard monaural pickups normally *cannot* be used to play stereo records. This is not too serious, however, because there is no logical reason for playing stereo discs to produce monaural programs. The important side of the picture is that 45-45 cartridges *can* be used to play monophonic recordings without damage.

A 45-45 pickup is necessarily designed to move freely in both vertical and lateral directions. Hence, a 45-45 cartridge such as that shown in Figure 9 will convert monaural transverse variations into corresponding electrical signals. Also, a stereo pickup can play 45-45 discs monaurally by combining the signals of both channels to form one. Thus, the Westrex and monaural systems are partially compatible.

Stereo-monaural compatibility must certainly be considered when making the stereo switch, for the unsuspecting record fan may blindly purchase stereo records, take them home, play them with a monaural pickup, and then find that he owns some five dollar discs that are good only for sailing through the air on a windy day. Consequently, the first component to be purchased when making the switch to stereo is a 45-45 cartridge.

Making The Stereo Switch

Several types of cartridges are available, such as the ceramic, crystal, and magnetic. If a cartridge has a low output, e. g., magnetic, a preamplifier is needed to bring the output up to a useable level. Any final selection will depend upon what equipment you already have; hence, you should consult your dealer about which cartridge to buy.

After the cartridge, a second amplifier and speaker system must be added before 45-45 recordings can be enjoyed as stereophonic programs.

Even though both channels are full range, the second speaker need not be a perfect match for your present one, but both must have similar characteristics to give best results: high frequency responses should be identical, and the low responses should be similar down to 100 cps; their efficiencies should be nearly the same to maintain reasonable balance between the two channel outputs.

In the same vein, the second amplifier should have characteristics similar to your present one—especially in frequency response and distortion tolerances. Though not absolutely essential, a stereo adapter is desirable from a standpoint of operating ease, for it "ties" your two amplifiers together to permit single-knob control of channel balancing and overall volume.

Your present turntable may also pose a problem. Assuming that you have added a stereo pickup, a second amplifier, and a second speaker to your phonograph, you will quite possibly hear a low rumbling noise when listening to stereo recordings. It is not the record; it is your turntable, and the noise you hear is called *vertical rumble*. Because standard cartridges respond only to lateral movements, vertical rumble was no problem in monophonic reproduction. But stereo pickups move both vertically and laterally. Consequently, any vertical vibration in the turntable will be reproduced along with the intelligence. The only solution is to buy a turntable that is designed to minimize vertical rumble; most are being so designed at the present time.

In addition to the preceding "add-on" plan for converting to stereo, the consumer has two other alternatives: 1) he can purchase a single unit stereo phonograph, or 2) he can buy all new individual components. Naturally, the consumer is concerned with comparative costs of the three plans.

(Continued on Page 28)

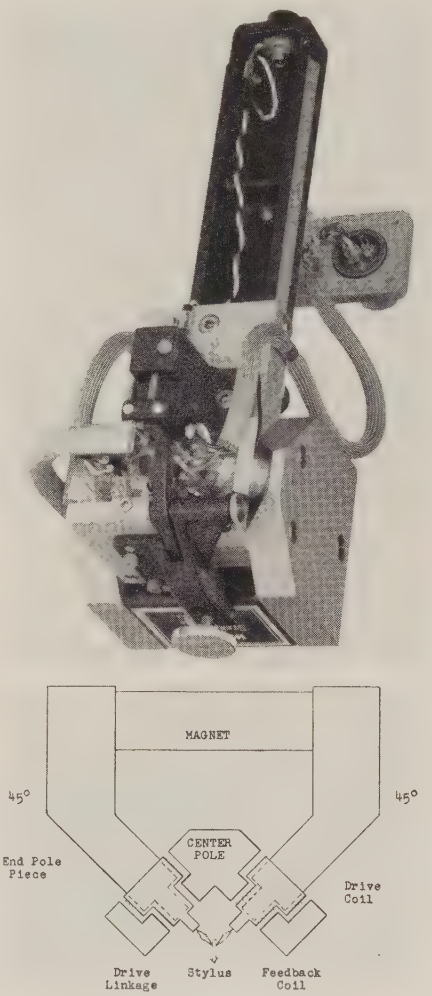


Fig. 6. Bottom and simplified front end views of Westrex 3B stereo recording head. (Courtesy Westrex Corporation)

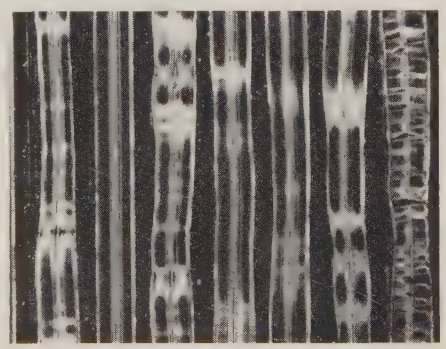


Fig. 7. Microphotograph of 45-45 grooves containing stereo information. (Courtesy Westrex Corporation)

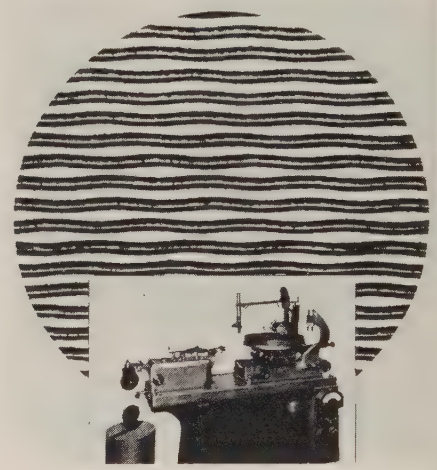
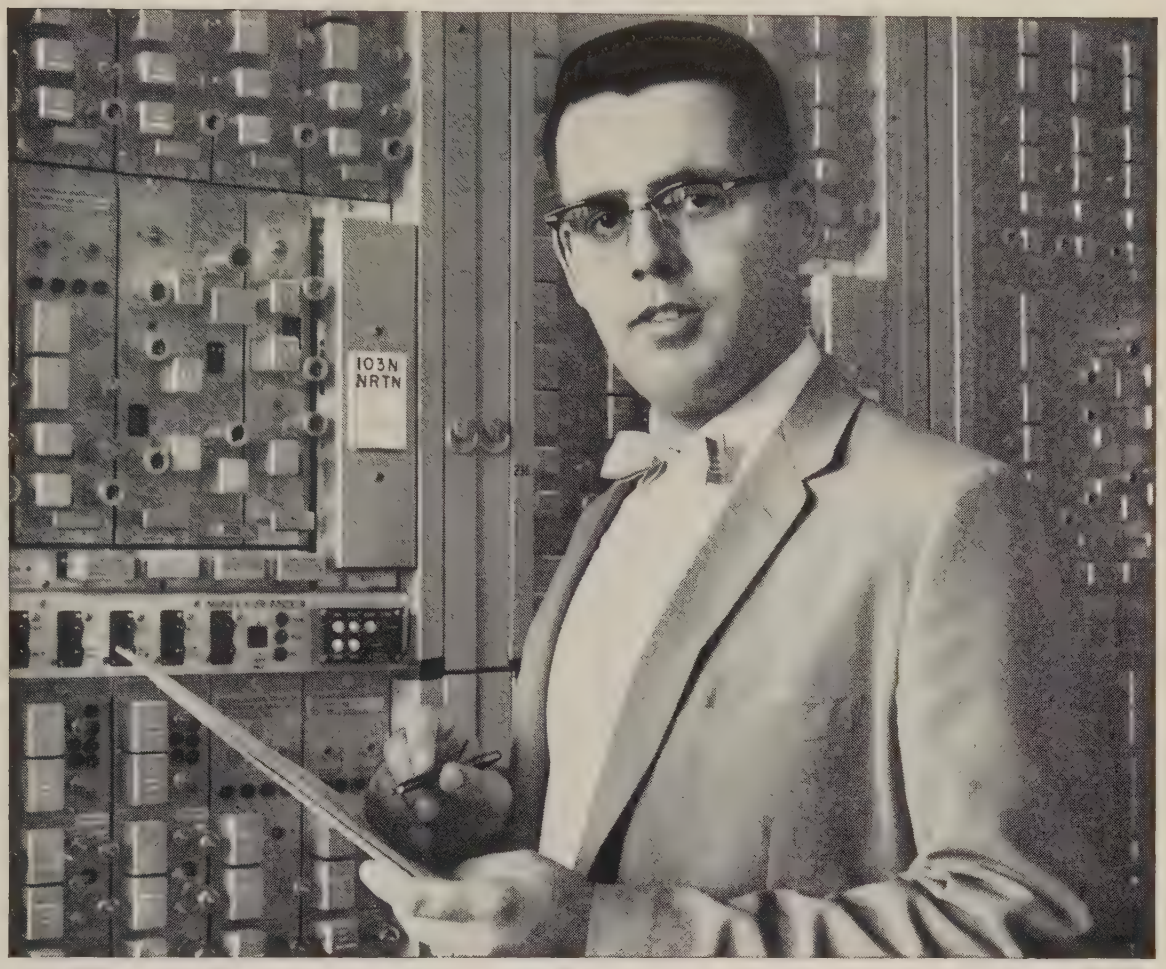


Fig. 8. Microphotograph of monaural recording grooves; insert, monaural recording machine developed by Bell Labs for use in its research on speech during the 1930's. (Courtesy Bell Telephone Labs)

A Campus-to-Career Case History



"I wanted a job I could grow with—and I've got it"

H. James Cornelius graduated from Swarthmore College in 1954 with a B.S. in Electrical Engineering. He's been "growing" ever since with the Bell Telephone Company of Pennsylvania.

After an initial 44-week inter-departmental training course, Jim was made Facility Engineer in charge of the fast-growing Norristown-Pottstown area. In that capacity, he engineered over half a million dollars' worth of carrier systems and cable facilities between major switching centers in Pennsylvania.

Today, he is one of 50 young engineers from the Bell Telephone Companies chosen to attend a special Operating Engineers Training Program at Bell Laboratories. This 19-month course of study—with full pay—deals with advanced techniques and new concepts in electronics which signal a new era in telephony. It involves both classroom theory and practical laboratory applications.

When Jim and his colleagues return to their companies, they'll review major engineering projects. This will assure the best use of equipment for current engineering, as well as for expected new developments in communications.

"I wanted a job I could *grow* with," says Jim, "and I've got it. I can't think of a better place than the telephone company for an engineering graduate to find a promising future."

Many young men like Jim Cornelius are finding rewarding careers with the Bell Telephone Companies. Look into opportunities for *you*. Talk with the Bell interviewer when he visits your campus. And read the Bell Telephone booklet on file in your Placement Office.

BELL TELEPHONE COMPANIES

(Continued from Page 26)

Based upon radio supply houses' current prices—not wholesale—, a high quality monaural system costs approximately $420; the stereo add-on plan would run an additional $320; a single-unit stereo system would cost $300-$400; and individual components would total approximately $700. If the reader is in a state of shock at this point, he should keep in mind that the less discriminating audiophile can easily chop the aforementioned costs to approximately $150, $100, $200, and $300 respectively and still have a fair quality sound system.

After considering the initial investment in making the stereo switch, you must think about record costs. Name brand, domestic, 12″, 33 1/3 rpm recordings are normally sold for $3.98 to $4.98, and stereo issues of the same recordings sell for a dollar more. Foreign labels sell for $4.98 and $5.98 in monaural and stereo issues respectively. Is stereo worth the extra dollar?

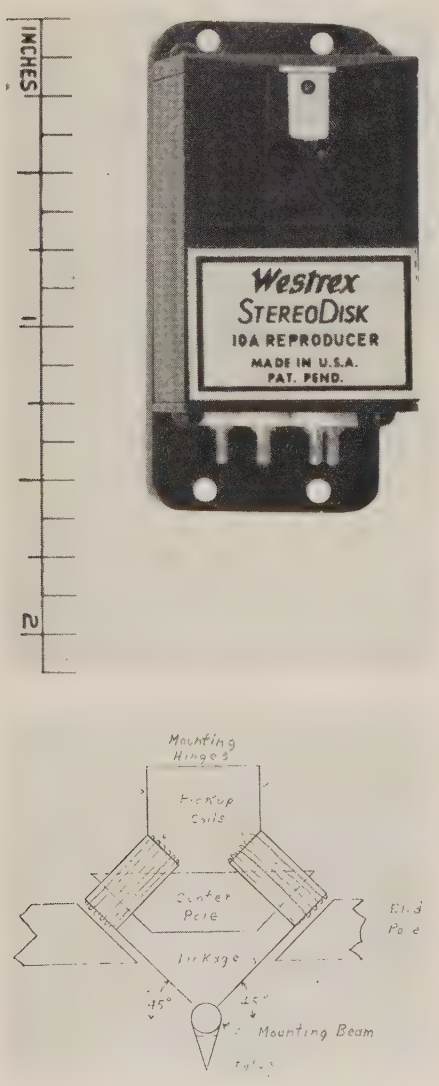


Fig. 9. Bottom and simplified front end-section views of Westrex 10A stereo playback cartridge. (Courtesy Westrex Corporation)

Does Stereo Have Merit?

The worth of stereo is, of course, a subjective consideration, but a few comments from experts in the audio field should give the reader an idea of what to expect from stereophonic reproduction. For example, J. P. Maxfield of Bell Labs has said, "I would rather hear a two channel reproduction flat to 6 kc than a single channel system flat to 15,000 cps; it is more pleasing, more realistic, more dramatic," and the Editor of *Radio-TV News* believes that "The psychological effect itself, even under lower quality conditions, far surpasses the best monaural LP."

Even more revealing is an excerpt from R. D. Darrell's review of Berlioz's *Grande Messe des Morts* (Westminster label): "Admittedly, even stereo (at least in two channels only) cannot encompass everything in this fabulous structure, yet in following the printed score my ears as well as my eyes noted innumerable details . . . which have been inaudible or ineffective in all previous recordings. The choruses . . . sing like angels, with the men never submerged by the women." Final comparisons between monaural and stereo reproduction, however, must rest with the individual.

Let us suppose that you have compared and decided that stereo is worth the extra cost. You are now probably wondering what types of stereo records are on the market. To the author's knowledge, the so-called "party record" has yet to appear beneath record store counters, but practically any other record imaginable is available. Currently, stereophonic discs can be categorized as "natural" and "gimmick" stereo.

Stereophonic Recordings

Gimmick sterephony relies upon wide channel separation to emphasize the dimensional effect and can best be described as a ping-pong game using sound as the ball. Some musical programing is ping-pong recorded, but most gimmick discs are novelty records which let you transform your domicile into a railroad yard, and auto race track, or even the jungles of Africa—take your pick.

Natural stereo, on the other hand, has moderate separation; it offers a solid front of sound and is more satisfying. The majority of stereo discs fall into this classification, and the audiophile has an unlimited choice in selection: classical, semi-classical, opera, operettas, broadway musicals, movie sound tracks, popular, folk music, and jazz.

Technically speaking, there are also both high and low grade stereo discs—just as with monaural records. Most low grade records, however, are a result of the recent stereo rush: some

(Concluded on Page 30)

from Deep space to Ocean floor

Vought offers this range to the young engineer

At Chance Vought the engineer's assignments range from the depths of the ocean to the farthest reaches of space . . . from hardware operating aboard the Navy's nuclear-armed submarines to space research vehicles still on the boards.

Here the engineer contributes to projects such as the record-smashing *Crusader* jet fighter series . . . the *Regulus* missiles . . . and advanced weapons, details of which are still classified.

Under the guidance of the Vought engineer, such weapons take shape. He supervises critical tests, and he introduces the weapons to the men with whom they will serve.

Engineers with many specialties share these experiences. Today, for example, Vought is at work on important projects involving:

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Deep Water and Deep Space open up Exciting Careers at Chance Vought

Outer space and ocean depths present a tremendous challenge to young engineers. Deep space and deep water are becoming new avenues of attack, and consequently broad studies are now going on at Chance Vought for safeguarding these approaches with advanced weapons systems.

Toward space security, Vought's propulsion specialists are analyzing nuclear and ionic power. Astronautics design teams are studying crew quarters for spacemen and devices for escape from orbit . . . drawing on the near-space cockpit and capsule experience of Vought's *Crusader* fighter developers.

Earth's ocean basins, too, are potential theaters of war. Under the Office of Naval Research, Vought engineers are seeking improved ways of detecting and identifying the submarine – a weapon they know well. Since 1953, U. S. Fleet subs have carried *Regulus* missiles and support equipment.

Engineers of all academic specialties can find at Vought an unmatched career area . . . as new capabilities are forged . . . weapons for deep water and deep space defense.

CHANCE VOUGHT AIRCRAFT
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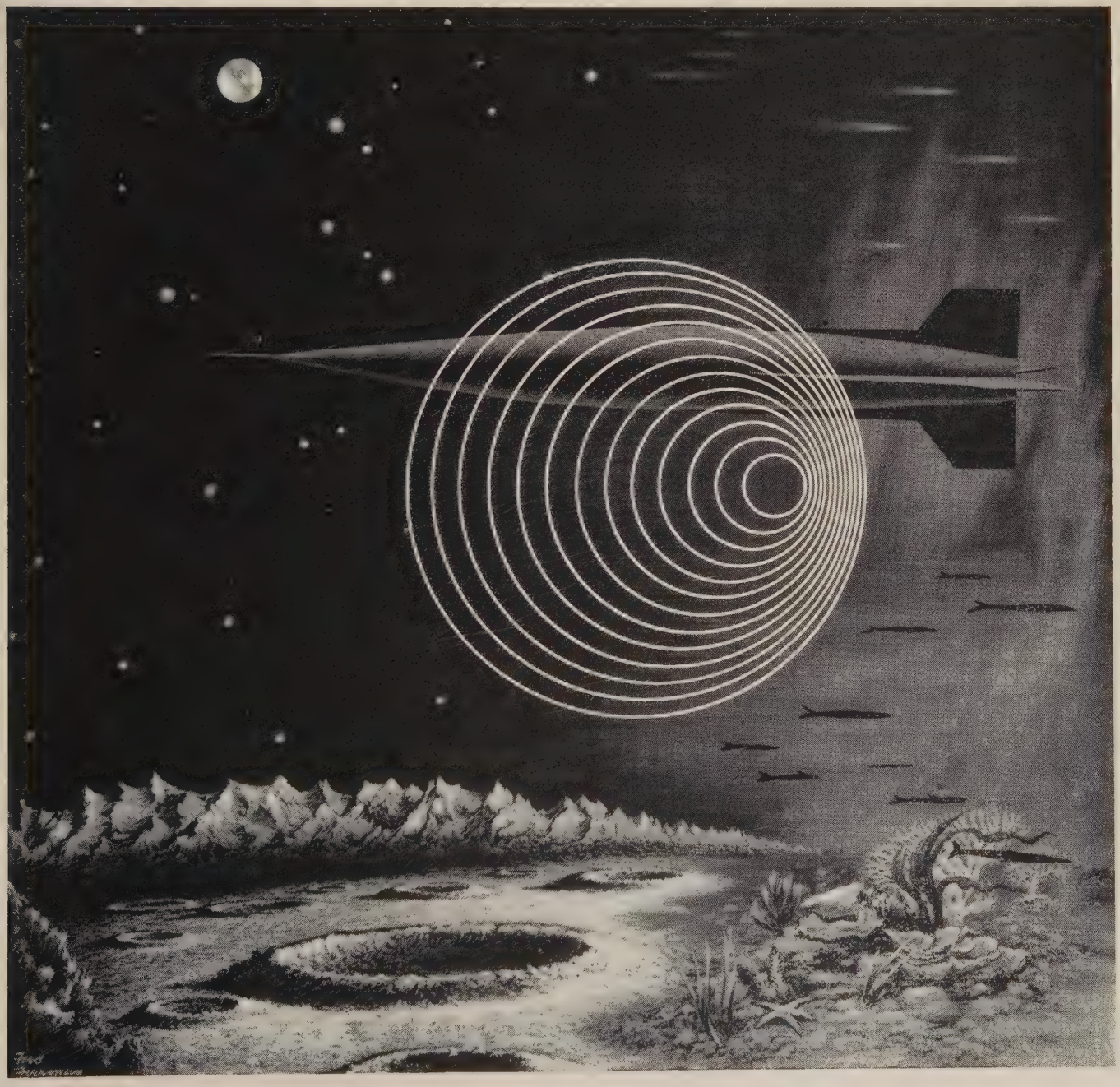


(Continued from Page 28)

manufacturers were unprepared for stereo, and in rushing to get their labels on the market, quality took a back seat. We should not forget, however, that the first LP's were also poor compared with present-day LP records. Actually it is surprising that in a comparatively short time many stereo recordings have been produced which approximate the quality of standard LP's. And as the recording industry gains experience in stereophony, improvements in quality can be expected.

Should You Wait?

Waiting to make the stereo switch until industry gains experience is much like postponing buying a color television set until more color programs are available. If you purchase a color set now, you can watch both black-white and color programing; if you switch to stereo now, you can listen to both monaural and stereo recordings. Even though stereo standards are still up in the air, it is doubtful that any *radical* changes or *significant* improvements in stereo playback equipment will be made for quite some time, so why limit yourself to one-dimensional sound any longer?

Liberation of the recording industry from a one-dimensional world of sound is already a fact, and without a doubt the radio - television industry will eventually be liberated also. Even now experimental work on three stereo broadcasting methods is under way: 1) the AM-FM or FM-FM, 2) the AM-Single-sideband, and 3) the FM-Multiplex methods. Among the three, FM-Multiplex has the greatest potential because the FM band has wider bandwidth allocation, and only one transmitting station is required.

Regardless of which stereo broadcasting method is adopted, the man who presently owns a stereo phonograph system will be prepared, for he will need to add only a stereo tuner at a cost of $80 and up to bring "stereocasts" into his home.

Whether it be stereocasting or stereo recordings, interest in stereophony is running high, and rightly so, for where monaural reproduction took one of our ears away, stereophonic reproduction has given it back.

Boxcar Detective

A new device may enable railroads to solve one of their most difficult problems—tracing rolling stock. The device attached to each boxcar will emit a unique electronic identity signal as the car passes a stationary electronic interrogator set up along the roadbed. The signal then is relayed to a central tracer location.

Summer Anti-Freeze Gains

Summer sales of anti-freeze are headed upward as U. S. motorists seek cooler summer driving. The permanent type of anti-freeze is used in car air-conditioning units. Estimates are that about eight per cent of the 1958 cars were equipped with air conditioners, and it is predicted this figure will climb to 15 per cent by 1960.

Outdoor Cooking Grows

Sales figures indicate Americans will leave their mechanized kitchens in record numbers this year for the joy of cooking over smokey outdoor fires. Grill manufacturers estimate they sold $100 million worth of outdoor cooking contraptions last year—and they expect the figure to triple in 1959.

Rail Know-How Moving North

It apparently takes Canadian know-how to handle those rare U. S. railroad construction jobs. A Calgary, Alta., firm says it has four new track maintenance jobs in this country. In 1958, the firm did work for 20 railroads in 18 states.

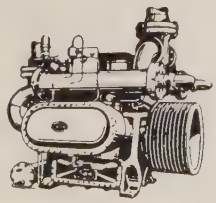
Won't your wife hit the ceiling when you come home tonight?"

"She probably will, she's a hell of a shot."

Plan YOUR FUTURE with

TRADE FRICK MARK

BACK OF FRICK EQUIPMENT STANDS OVER 100 YEARS' EXPERIENCE IN ENGINEERING, 75 YEARS' EXPERIENCE IN REFRIGERATION, AND 50 YEARS' IN AIR CONDITIONING.



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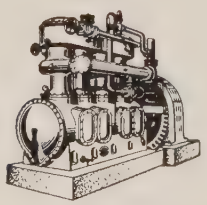

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COMING NEXT!

PROGRESS

by Jerry Hill

Progress, or the word, *progress*, as it is interpreted by man, is, in actuality, a vicious circle, and through his hypotheses, theorems, calculations, and computations, he may suddenly discover that two and two equal four . . . Once upon a time there was one of these men named Edsel Ford who was interested in progress. So interested was this Mr. Ford in progress that he veered off on a branch of it and started an institution of progress (if it may be referred to here as such) known as the Automotive Industry. . . . Although these automobiles were planned with the idea of putting the horse out of business, people said it couldn't be done.

. . . But it was, and everywhere were young people, happily sitting side by side in their single seat roadsters, were families out jaunting in their new four-door sedans. . . . Automobiles had arrived . . . progress . . .

The advent of the automobile made the road builders happy, because now they had a reason to build more and more roads. The advent of the automobile made many rural people happy, because now they got their mail delivered more frequently and with greater speed.

In fact, everybody was happier because the automobile didn't do things to the clean roads that its predecssor, the horse, did.

Everybody was happy . . . progress,

And man saw himself standing at a new threshold of science and engineering.

But, as progress encompasses all things, man found that the automobile passed its place as something useful and kept on (shall we say . . . progressing?) progressing.

The automobile had become more than merely a means of transportation.

The road builders were unhappy because they were running out of places to put roads.

The rural people were unhappy because "those hot-rodders with the noisy exhaust pipes" kept racing past and scaring their chickens.

Young swains used it to woo their loves.

So . . . not only was it a mode of transportation, but it had become a portable boudoir, a noisemaker, an air polluter, a method of crowding the highways, and, if used properly, a weapon.

Automobiles were constantly changing . . . they got bigger and roomier, they got longer and lower, they got fiashier and "sportier," and they got faster and faster and faster . . .

Progress . . .

But now, the automobile had taken such a position in this new era that thousands of people depended on it for jobs, and it was forever being changed to appeal . . . and sell . . .

This new civilization of man circled about a nucleus made up entirely . . . of automobiles.

What had started out as one man's idea for making mankind a little bit happier perhaps had become an obsession and a way of life.

Wait until the new models come out; they'll be so long that they won't be able to turn a corner, so wide that all streets will have to be one-way, and the big thing will be the high tail fins to give them stability while roaring down over-crowded, speed-zoned highways at fantastic speeds approaching 45 mph. They will have plastic bubble-domed tops, and look like cars from Mars . . . and they must keep changing, ever changing.

This is progress . . .

And one day, once upon a time, an automobile will probably invent a man.

There is only one answer. . . .

Tip from a pro:

"Pencils are any draftsman's most important tool. So use the *finest:* EAGLE TURQUOISE.® They hold their needle point for line after line of unchanging width. Their leads are smooth . . . make drawing easier. There's a full range of 17 grades. And in each grade, 100% uniformity. TURQUOISE is the pencil most pros prefer. Better use 'em yourself."

FREE SAMPLE! Write Eagle Pencil Company, Danbury, Connecticut, for a free sample TURQUOISE.

EAGLE TURQUOISE

PENCILS • LEADS • HOLDERS

THE ILLINOIS TROUGH

(Continued from Page 13)

into the indicating and recording instruments..

Unlike the antenna, the indicating and recording instruments will be of conventional design, and in most cases will require only standardization and installation. One example of the types of instruments that will be employed for both indicating and recording purposes is the oscillograph.

The Union Corner Site

The 220-acre radio telescope site, located at Union Corner, five miles SE of Danville, Illinois, was chosen by elimination of other possible locations and purchased by the University for $15,900. The site requirements were strict:

1. The ravine selected must be shaped closely to the desired parabola to decrease construction costs.

2. Power lines or other objects could not be present.

3. Electrical interference from radio and TV stations should be minima.

The site, located on a river bluff, is a shale valley 65 feet deep running north-south with a small stream flowing through it. It is fairly remote from interfering UHF channels with a 200-mile station-free area at 600 megacycles. The antenna itself occupies five acres; the rest of the 220 acres is necessary to eliminate interferences and provide privacy.

The valley has been surveyed with a straight north-south center line for the reflector, and over 32 test borings have been made. The ground will be graded to the parabolic shape desired (± 2 inches) with a 2% slope from north to south for drainage. A dam is being built north of the site to control flash floods. The stream will be straightened to run exactly north-south and carried by a concrete culvert through the center of the reflector base.

Project consulting engineers for contract specifications are Hanson, Collins, and Rice, Springfield. The major contracts will be for grading and surface water drainage, utilities, tower structures, and the main building.

Dr. Swenson's group and the State Geological Survey independently examined topographical maps to find suitable areas. The sites were initially inspected from an airplane. Those sites surviving the first examination were subjected to a radiation interference test with equipment developed by Dr. Davidson. Every good valley seemed to have a power line running through it, and the last one available was the Danville site.

Essentially, the function of the Trough will be to look into the heavens, past the Milky Way, past our neighbor galaxies, past stars which even our most powerful optical telescopes cannot discern, and to record these observations on astronomical charts for further research.

Radio telescopes are capable of "seeing" through the center of a galaxy which would be blurred optically. The Trough will provide valuable facilities for teaching and research. It will extend and verify the radio astronomy catalogs obtained by the radio telescopes in Austria, England and Holland. Be-

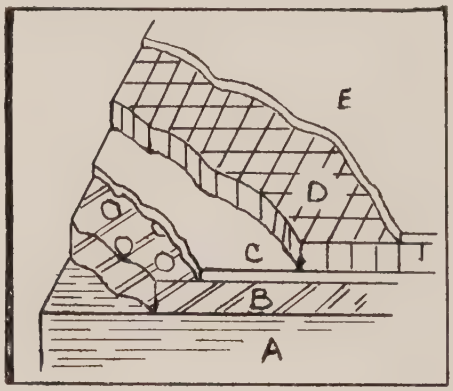


Fig. 5. A layer of perforated steel mats (B) will be laid over the graded shale base (A). One-to-two-inch mesh screening (D) will act as an electrically homogenous reflector. It will be protected by two layers of plastic (C and E).

ing able to detect weaker sources, this telescope will provide valuable new information about the size and shape of our galaxy and all of the universe.

Present radio telescopes have been able to receive signals only 1/100,000,000 as strong as an ordinary television signal. It is believed that the Trough will do even better and receive signals from point sources so far away as to be almost beyond the conception of mortal man.

"This telescope may provide the additional information necessary to specify more exactly the nature of the astronomical universe," says Dr. McVittie. Whether the new instrument, to be completed by 1961, along with other radio telescopes of smaller size already in operation, will simply add to the present picture of the universe or radically alter it can only be told in the future.

Russian Road Plans

The Soviet Union plans to lay more than 43,000 miles of highway by 1965. Included in the system will be four-lane, grass-divided trunk roads of cement-concrete radiating from Moscow and other principal cities. The longest will stretch 620 miles from Moscow to Stalingrad.

TECHNOCRACKS

And then there was the Arts student who let his EE roommate fix him up for a date with Allis-Chalmers.

* * *

Comment overheard at Military Ball:

She: "What's the difference between dancing and marching?"

ROTC Student: "I don't know."

She: "I didn't think you did. Let's sit down."

* * *

Wisdom: Knowing what to do.
Skill: Knowing how to do it.
Virtue: Not doing it.

* * *

She was only gearmaker's daughter, but she could outstrip them all.

* * *

Managing Editor: My girl friend never does anything wrong.

Editor-in-Chief: She doesn't?

Man. Ed.: Nope—she says if a thing is worth donig at all it's worth doing right.

* * *

Fred: "May I take you home?"

Inga: "Sure. Where do you live?"

* * *

"I know a guy who swallows swords."

"That's nothing, I inhale Camels."

* * *

The instructor was teaching a cute young thing to drive.

"This," he said, "is the hand brake. You put it on quickly in case of an emergency."

"Oh, I see," she giggled, "It's like a bathrobe."

* * *

Joe Engineer decided to reform. He cut out smoking the first week. The second week he cut out drinking. He cut out women the third. The fourth week he cut out paper dolls.

* * *

The elevator was tightly jammed when a girl said fiercely: "Take your hands off me, you louse! No, not you! YOU!

* * *

And as they say in mechanics—"Every couple has its moment."

* * *

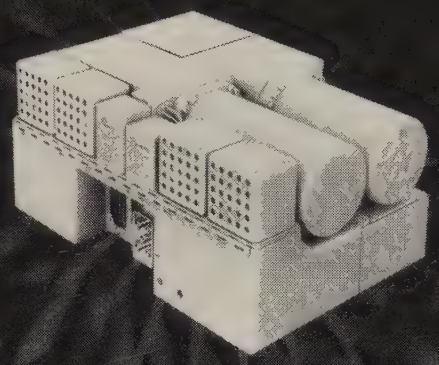
A circle has no corners.
An oval has no corners too.
But not so nearly no corners as a circle has.

* * *

"Your girl is spoiled, isn't she?"

"No, it's the perfume she's wearing."

PRODUCT OF CREATIVE ENGINEERING



This electronic centralized air data computing system, pioneered by AiResearch engineers, now enables aircraft to operate at maximum efficiency continuously. By sensing air conditions surrounding the airplane, it automatically makes in-flight adjustments and feeds vital information to the pilot. This centralized combination of transducers, computers and indicators is the most complete air data computing system ever produced by any manufacturer.

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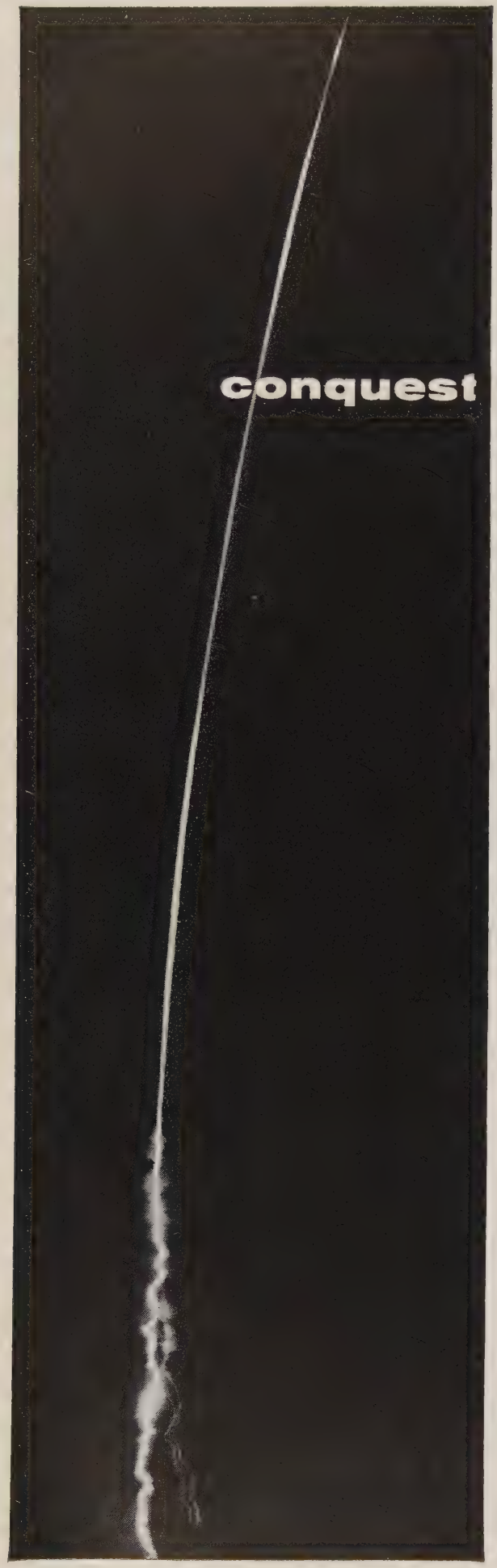

conquest of the thought barrier

Over the years, we have been hearing of many "barriers" in science . . . the sound barrier, the water barrier, the thermal barrier.

Of all the barriers, the hardest one to break through has always been the thought barrier. Every one of these "barriers" has been conquered by men to whom the word, impossible, means: "hasn't been done, *yet*."

The sound barrier is a shattered concept, as discredited as the phlogistic theory.

Don Campbell's *Bluebird* stopped all talk of the water barrier.

The heat of air friction against the metal "skin" of an airplane was supposed to create a heat barrier at Mach 3. Materials now in production can safely withstand the much higher temperatures involved in flight at Mach 5.

Today the thermal barrier is being called the "thermal thicket"—evidence in itself that no barrier exists.

An interesting point that all of these "barriers" have in common: each was conquered with the help of nickel-containing alloys.

This is not surprising when you stop to consider how many useful properties and combinations of properties are offered by the various nickel alloys:

Corrosion resistance to a wide variety of solids, liquids and gases . . . strength at high temperatures . . . toughness at sub-zero temperatures . . . unusual electrical properties . . . ability to protect product purity . . . spring properties.

When you are faced with a metal problem, investigate Nickel and its alloys. Inco's List "A" and List "B" contain descriptions of 377 Inco publications which are available to you, covering applications and properties. For Lists "A" and "B", write Educational Service.

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Analytical problems are encountered in a wide range of engineering activity* as a prelude to solving the problems of design and development of environmental systems, engine controls, auxiliary power units and other vital equipment which Hamilton Standard will provide for such "out-of-this-world" aircraft as the North American B-70 bomber and F-108 interceptor. These assignments require outstanding engineers who will be working on the threshold of space. Their careers will progress as the space age advances.

The project system — small groups of engineers working together as teams provide the creative, stimulating atmosphere necessary in solving the problems of the space age.

*aerodynamics	therodynamics	control dynamics
heat transfer	stress analysis	mechanical analysis
mechanical metallurgy	vibration	systems analysis
fluid dynamics	measurement techniques	instrumentation development

reliability and statistical methods
IBM and analog computing; data deduction

If you are interested in designing and developing such products as these, contact Timothy K. Bye, Engineering Personnel Coordinator, or arrange for an interview with your college placement officer.

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DIVISION OF UNITED AIRCRAFT CORP.
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NEW JET QUEEN OF THE WORLD'S AIRWAYS

The beautiful Convair 880 Jet-Liner, soon to be joined by her sister ship, the Convair 600, will begin serving the world's leading airlines next year. Fastest commercial transports of all, they are products of Convair-San Diego engineering imagination.

Other projects here include the F-106 Delta Dart, fastest and highest-flying jet interceptor. In addition, our engineering and scientific teams are engaged in studies of manned satellite vehicles, STOL and VTOL aircraft, and nuclear propulsion for weapons systems. These advanced programs, plus joint projects with other divisions of General Dynamics Corporation mean added challenge and responsibility for engineers and scientists at Convair-San Diego.

GRADUATES AND UNDER-GRADUATES

will find vigorous climate for development and progress at Convair-San Diego. The company has a distinguished history of flight spanning more than a third of a century, and an unlimited future is assured by dynamic policies and progressive, forward-looking management. Sound balance of commercial and military contracts means added stability.

San Diego, California, is a wonderful place to live. Its extraordinary climate varies from cool, breeze-swept beaches, to warm, dry deserts. Hiking and camping are minutes away in the nearby Laguna Mountains, and charming Old Mexico is just 15 miles south of the city.

We offer career opportunities to graduate and undergraduate students majoring in aeronautical, mechanical, electronic, electrical and civil engineering, and to graduate students majoring in physics and mathematics.

An interesting booklet describing engineering careers at Convair-San Diego is available upon request. Write to Mr. M. C. Curtis, Industrial Relations Administrator,

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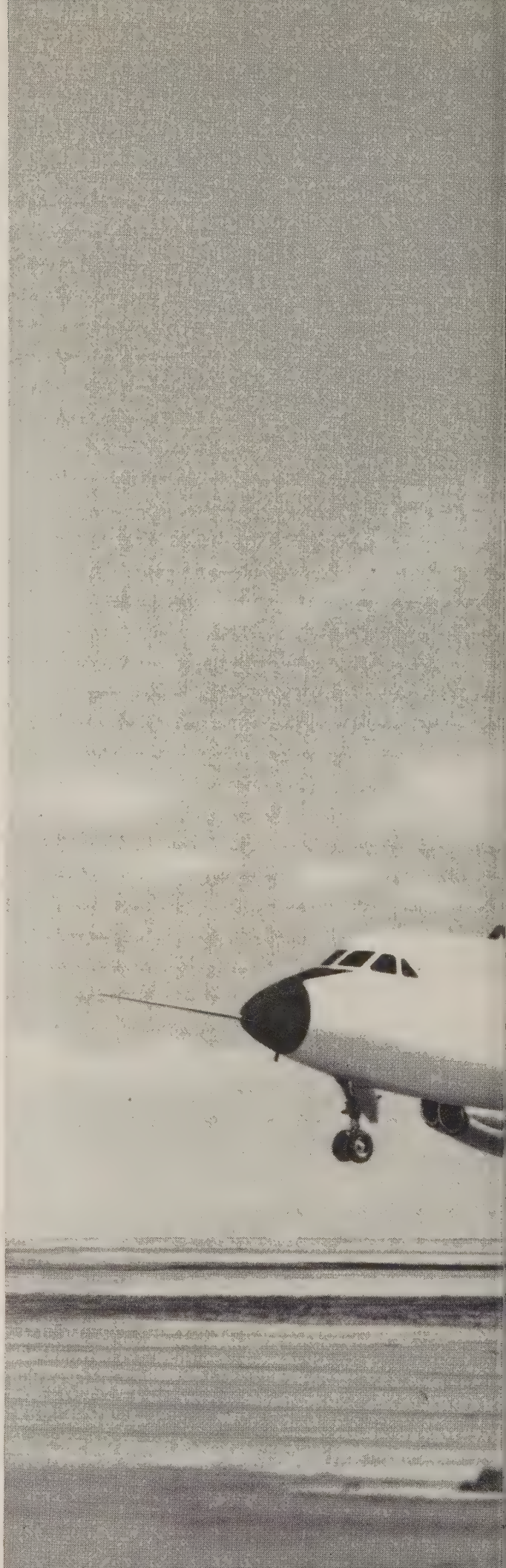


JANUARY 27, 1959—CONVAIR 880 LIFTS OFF RUNWAY ON MAIDEN FLIGHT, USHERING NEW DIMENSION IN JET-AGE TRAVEL.

THE RADIATION AROUND US

by Larry L. Hooker

At the present time, man is standing at the doorway to space. In the past year and a half he has been probing deeper and deeper into the secrets of space. The Vanguards, the Discoverers, the Explorers, the Sputniks and the Lunics all have been equipped with a wide variety of instruments which have answered many of man's questions about space. Even with this vast variety of data, the most interesting and least expected result of man's exploration of the vicinity of earth is the discovery that our planet is ringed by two regions of high energy radiation extending many thousands of miles into space.

The story of the radiation bands began long before the first satellites were put into orbit. It was known in 1953, through the use of high altitude balloons, that a radiation zone existed over Newfoundland, beginning at an altitude of 30 miles. No one knew what the radiation was or where it came from.

The International Geophysical Year gave scientists their first chance to really investigate this radiation. In the summer and fall of 1957, a number of high altitude balloons were launched in the Arctic and Antarctic regions. These tests established that radiation exists in the southern as well as the northern latitudes.

The American scientists were firmly convinced that the radiation existed at much higher altitudes than those tested. These scientists obtained priority to put a cosmic ray detector in the satellite, Explorer I, launched January 31, 1958.

In the first reports from the tracking stations, the intensity of the radiation increased with altitude as many scientists had expected. However, several weeks later, when the satellite was passing over the equatorial zone, the apparent counting rate was very low and in several cases dropped to zero for several minutes. Yet, when at lower altitudes over the same region, the rate had reasonable results of 20-30 counts per second. The instrument seemed to be performing properly, but no one would accept the theory that cosmic rays do not strike the upper atmospheres over the tropics.

On March 26, 1958, Explorer III was put into orbit carrying the same cosmic ray counter as was in the first satellite. This satellite confirmed Explorer's I's results. At altitudes of 200 to 300 miles the count was low and at 500 to 600 miles the apparent rate descended quickly and then dropped to almost zero. For the next several days the scientists pondered over these baffling results. Then suddenly one of them realized the fallacy in their analyzation of the data—a sufficiently high level of radiation could jam the counter and send the apparent counting rate to zero. Instead of finding a lack of radiation, the satellites had found an enormously high level of radiation. Following this new theory, the scientists gained much knowledge from Explorer III by studying at what altitudes the counter jammed. The satellites proved that the radiation zone stretched from at least 34° north to 34° south of the equator.

From this data, several scientists suggested that the radiation consisted of charged particles, presumably electrons and protons, trapped in the earth's magnetic field. To advance this theory further, the scientists felt that when a fast moving charged particle enters the magnetic field, it describes a corkscrew path around a magnetic line of force. When it reaches one of the earth's poles, the particle's trajectory flattens out and then continues its corkscrew journey on the other side of the earth. These particles slowly drift around the earth as they corkscrew from hemisphere to hemisphere. An electron drifts from west to east and a proton in the opposite direction. Within several days or weeks, the particles will collide with atoms of the atmosphere, slow down and fall into the lower atmosphere.

In order to prove these theories, it was necessary to build instruments with a much greater range. A Geiger counter with a casing of one millimeter of lead was put in the Explorer IV. This instrument was capable of reading a much higher intensity of radiation. Explorer IV was launched July 26, 1958, and established an orbit between 50° north and south of the equator and at altitudes up to 1300 miles. The radiation intensity contours were found to follow the shape of the earth in the equatorial zones, but as they approached high northern and southern latitudes, they swung outward and then inward and then sharply outward again. These contours form horns that reach down to the earth in the zones where the northern lights appear.

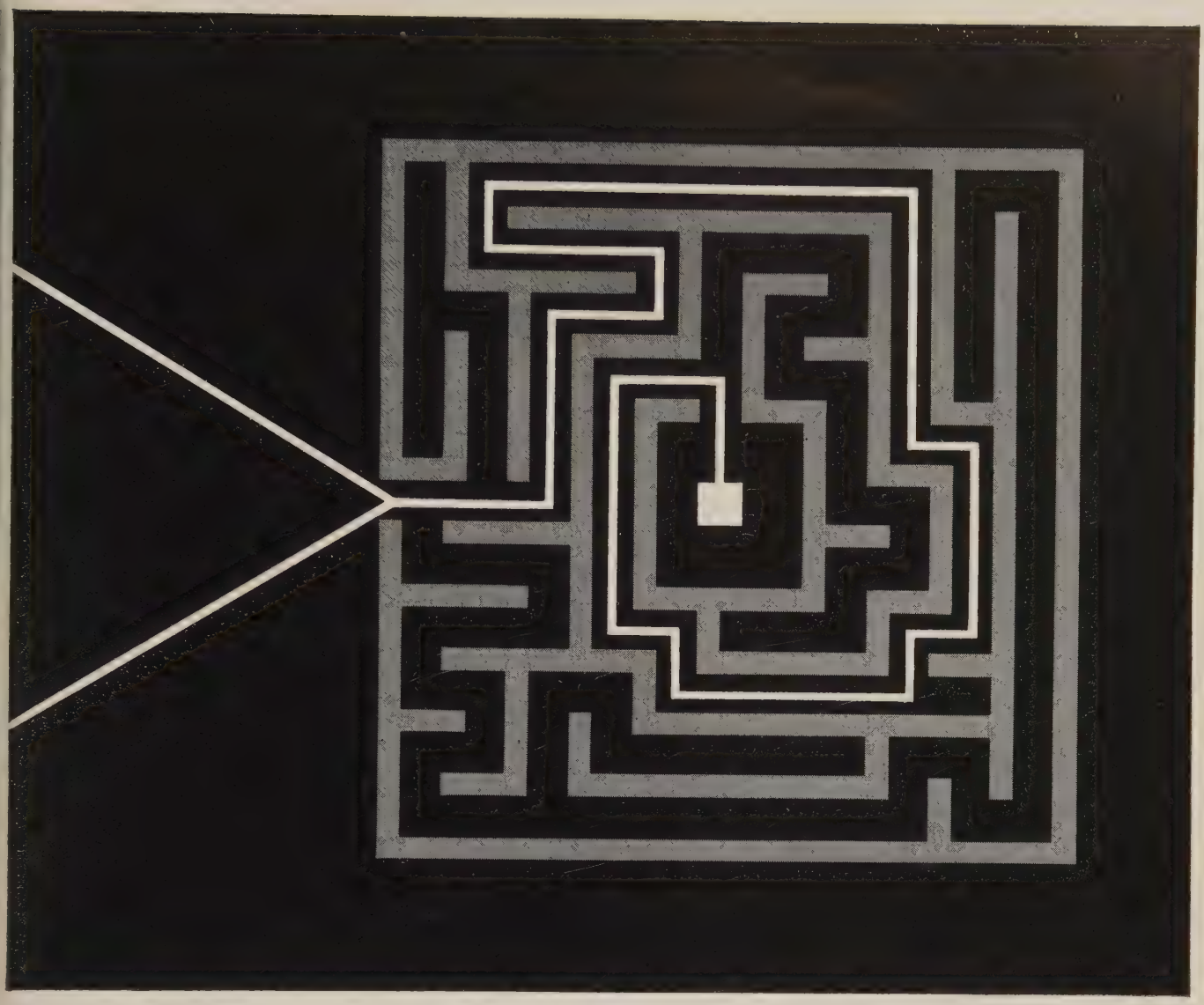
On October 11, Pioneer I, America's first lunar probe, carried instruments out to 70,000 miles. Its equipment showed two regions of high intensity radiation. The inner belt peaked at about 2,000 miles and the outer one at 10,000 miles. Beyond this range the radiation dropped off quickly and showed practically nothing past 40,000 miles. The maximum intensity of radiation in each belt is about 25,000 counts/sec., or equivalent to 40,000 particles/sq. cm./sec.

It is a fairly well accepted theory that these particles result from the large explosions frequently observed on the sun. These particles are hurled toward the earth where they are trapped by the earth's magnetic field. The radiation belts can be likened to a leaky bucket constantly being refilled from the sun and draining away into the atmosphere. A particularly large influx of solar particles causes the bucket to "slop over," mainly in the auroral zone, causing the visible northern light displays. The normal leakage may cause the airglow which often faintly illuminates the night sky and may also account for some of the high temperatures which have been observed in the upper atmosphere.

Many of the scientists were puzzled why there should be two belts of radiation. To explain this, scientists have suggested the following theory: It is felt that the outer belt is composed of the protons and electrons from the sun, but, undoubtedly, neutrons are also given off in the sun's explosions. These uncharged particles are unaffected by the magnetic field, pass through and continue toward the earth. For a still unexplained reason, these neutrons decay, at a height of about 2,000 miles, into protons and electrons and are then attracted by the magnetic field forming the second belt.

Measurements taken during 1958 showed a maximum radiation intensity

(Continued on Page 40)



A RESUME IS A TWO-PARTY AFFAIR

Throughout your engineering career, the name of the first employer appearing on your resume can be as significant as your education. But, in selecting that first employer, you should also consider his resume.

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This is an all too brief resume. It would be hard to associate yourself with a company that offers the engineer greater choice of assignment. Write us about your interests — or see our representatives when they visit your campus.

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(Continued from Page 38)

of between 10 and 100 roentgens per hour, depending on the still undetermined proportions of electrons to protons. A human exposed to only 10 roetgens in two days has only a 50% chance of survival; thus, the radiation belts obviously present an obstacle to space flight.

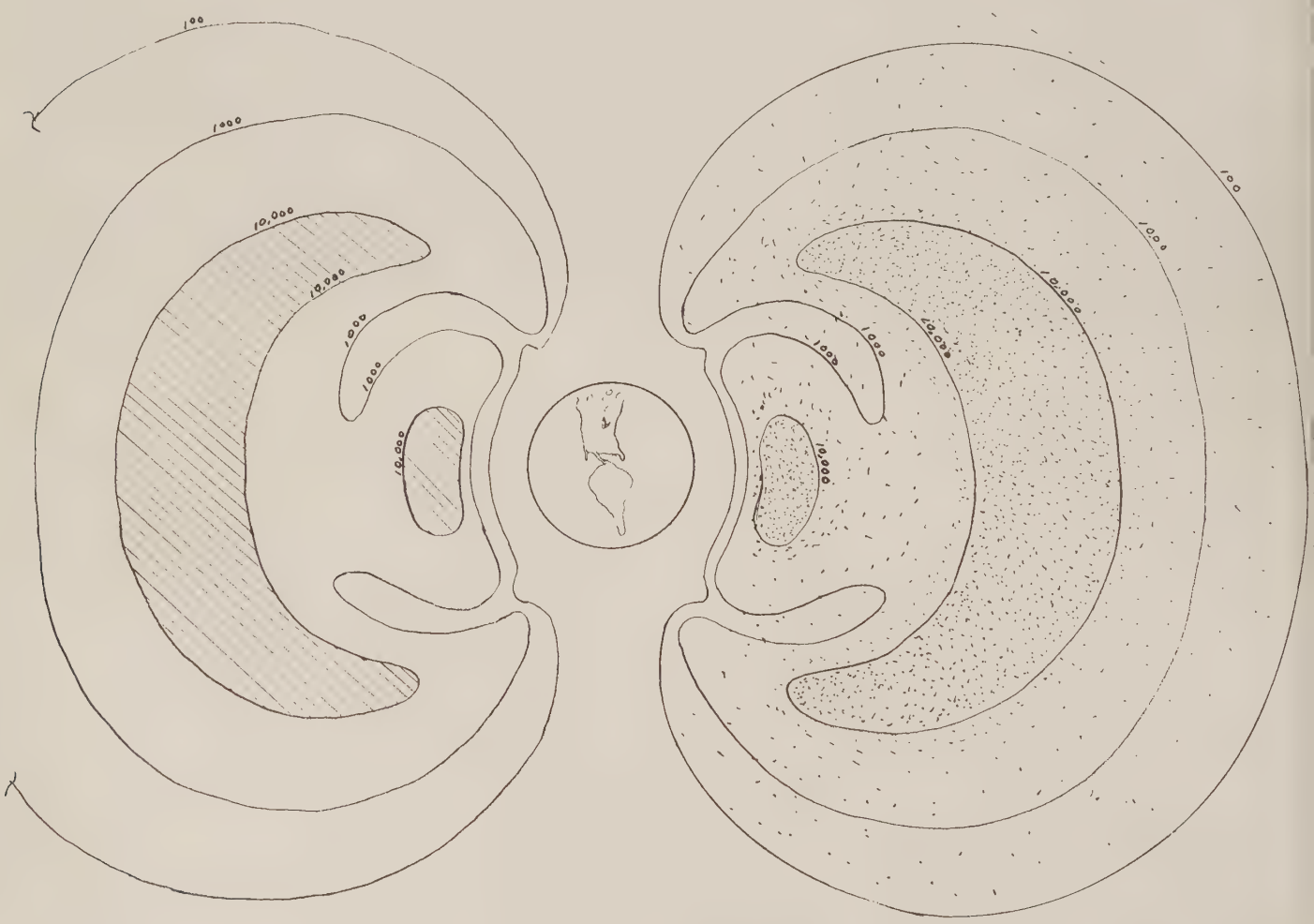
This brings up the big question—what can be done to protect space explorers from this new-found menace? Are we willing to cancel out all hope of human space flight? Very few scientists are willing to accept the latter choice; instead, they have suggested three methods of combating the deadly radiation.

The first method is probably the one that most of us would think of; namely, putting a protective shield around the rocket. Rocket experts agree that they eventually could produce rocket engines capable of lifting a rocket covered with ¼" of lead off the earth and into space. This would protect the men in the rocket from a large percentage of the radiation, but probably not from the areas of maximum intensity where radiation is potent enough to penetrate several inches of metal. This is a major drawback—if we later find the zones of maximum intensity change from year to year, we would be unable to keep a constant track on where they were in space.

The second method proposed seems to be the most suitable at the present time. If rockets were fired from the vicinity of the north or south poles, they would avoid the radiation bands altogether. We immediately see the transportation difficulties involved in this method along with many other problems, such as cold weather effects on rockets and limited suitable launching weather.

The third proposed method is strictly a theory developed by Dr. Singer of the University of Maryland. Dr. Singer feels that if the radiation bands prove to be too great of a threat to space navigation, they could be removed. This sweeping of the sky could be achieved by firing a large satellite of heavy metal into an orbit that would keep it within the doughnut shaped belts. Since the belts' particles are moving in spiral courses near the speed of light or about five times around the earth per second, they will have many chances to hit the satellite. Those that hit will be slowed down so much that they will fall out of the belt, and in a few months or years, both belts will be nearly gone. Dr. Singer feels that once the belts are destroyed, they will not build up to their present strength for another 100 years.

No one knows which of these methods will be the most satisfactory, but man still has a great deal of studying to do on the radiation bands. Possibly more extensive research will uncover or bring to light new methods of coping with the two radio-active doughnut shaped bands circling overhead. No matter how tough the problem looks, scientists feel that they will be landing men safely on other planets within the next ten years.



STRUCTURE OF RADIATION BELTS AND INTENSITY

Contour Lines are Calibrated in Counts Per Second

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

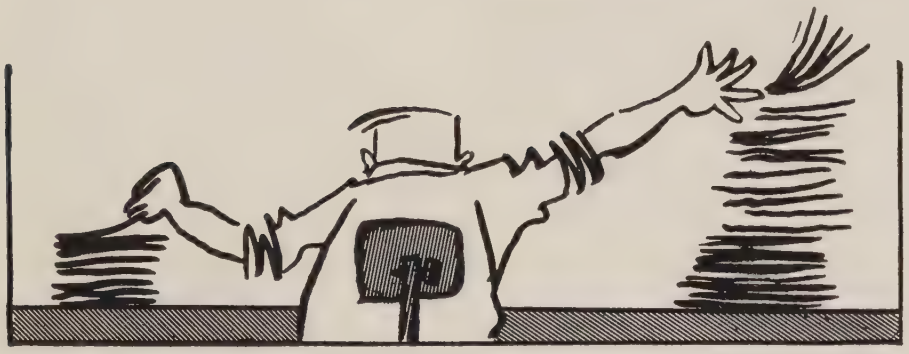
In this fast-moving age we find that we can no longer insure leadership... or even survival... by doing things the traditional way. If there's a better way, we must find it.

Our DC-8, C-133, Thor, Nike-Hercules, Genie, Sparrow and other aircraft and missiles are all the finest of their type and time. But their success, and that of our many new projects, depends on superior engineering.

That's why I'm looking for engineers dedicated to quality work. Only through such dedication can the extra performance and reliability of our products be attained. If you feel as we do about this principle, we'd certainly like to hear from you in regard to a future at Douglas.

Write to Mr. C. C. LaVene,
Douglas Aircraft Company, Box 600-M
Santa Monica, California

Skimming Industrial Headlines



Edited by The Staff

Potential of Water

Local, state and federal authorities are taking a longer look into the potential of water resources, reports Engineering News-Record.

One of the most significant advances in over-all planning in 1958 occurred at the federal level when a rivers-and-harbors bill included a broadened water-supply concept. For the first time, the Army Corps of Engineers and the Bureau of Reclamation are allowed to provide water storage capacity for future needs in their new reservoirs.

Out of Texas (drought-plagued in recent years, but flood-washed in 1958) came a real contribution to partnership-type, over-all river planning. The state-created Trinity River Authority came up with what is believed to be the first comprehensive basin-wide river program in the U. S. to be developed at local level.

Long-Range Development

The plan involves cooperation of local, state and federal authorities. It covers long-range development of the entire 18,000 square mile Trinity watershed, with due consideration for water supply, siltation control, flood control, navigation, pollution abatement and soil conservation.

That there is a need for a longer look into the future potential of water resources can best be illustrated by federal work in the Columbia River area, the magazine states.

A little more than ten years ago, there had been a feeling that Bonneville and Grand Coulee Dams generated more power than the area could absorb for many years.

However, when rising power demand proved the assumption false, McNary Dam was begun. Soon afterwards came Chief Joseph and The Dalles, both now virtually completed. And last year, construction was started on what is believed to be the last federal project on the Columbia River's main stem, John Day Dam.

Awareness of Problem

A growing awareness of sewage treatment and pollution problems is indicated by activity at state and local level—in Pennsylvania, Texas, Kentucky, Vermont, Washington, Tennessee, California, to name a few states.

But everything is not bright in the pollution picture. Public Health Service statistics show that although sewage treatment plants are going up at a faster clip, the need for them is growing even faster.

Industrial activity in water pollution is promising. One company announced the defeat of a nylon-wastes problem in Pensacola, Fla., after two-and-a-half years of research and development work on this problem. And at Bound Brook, N. J., another treatment plant was opened to handle "waste that couldn't be treated."

A simple treatment plan has been considered by the Ohio River Valley Water Sanitation Commission for the control of the concentration of untreatable chloride wastes in the Ohio. The scheme is simply storage of the waste at the point of origin for later release in amounts and at times picked to avoid overloading the river.

This method could also help control other pollutants. The commission is also considering it for control of taste and odor-producing substances.

Editor's Note: Watch for an article on water reclamation coming soon.

Aid To Motorists

A new electronic device attached to an automobile's steering column or instrument panel will remind motorists to turn off their car lights. As soon as the engine is turned off, the device automatically illuminates the word "Lights" on its dial if the bright lights, dimmers or parking lights are left on.

Original 'Chiseler'

The original "chiseler" was a European native of medieval times who used a cold chisel to achieve dishonest ends. He used the chisel to clip the edges of metal coins. Then he melted and remolded his collection of clippings into new coins.

Squirrel, Power Saver

A company has come up with a product for utility poles that will cut down on squirrel deaths and end power failures, line shorts and fires. Squirrels with their affinity for power line poles and transformers, are often welded to the spot when they nuzzle up against wires carrying 7,200 volts. Now, an insulating cover can be fused to the metal of the transformer with just enough juice coming through to give the squirrel a discouraging tickle.

AM Radios For Stereo

To enjoy stereophonic music, don't discard that old AM radio. No matter what its make, type or vintage, it will be usable for stereo reception if present plans work out. The plans call for lining up any two radios, even portables, for stereo use.

World's 'Longest' Shortcut

The world's longest shortcut, a tunnel from the French to Italian borders of Mont Blanc, will eliminate five-to-nine hours of driving time between Italian cities and France or Switzerland. The 7.5 mile tunnel will be three times the world's highway tunnel record, and will by-pass the 97.5 mile tortuous Alpine road from Chamonix, France, to Entreves, Italy.

aster Bus Service

Reserved lanes for busses only are beoming a trend in cities around the ountry. Cincinnati began a 30-day rial on one of its busiest downtown treets for the distance of five blocks. Between seven and nine a.m. and four nd six p.m., one lane is reserved for ransit vehicles—with no standing or topping allowed. Louisville, Ky., and Pittsburgh, Pa., have conducted simiar tests.

Plastic Torpedoes

The U. S. Navy is using fiberglass-einforced plastics for torpedo launchrs and torpedo tubes. Corrosion resistnce, high strength and simplified fabication are the reasons for turning to he new material. Wartime scarcity of non-corrosive metals was also an imortant incentive.

Built-In Deodorant

A new odor-fighter, supplied as a soution, can be applied to textiles before hey leave the mill. Developers of the extile agent claim it will kill the two ypes of bacteria that cause the unpleasant ordors. The new odor-fighter s said to resist dry cleaning and laundering, but to be somewhat affected by hlorine bleach.

Portable Office Duplicator

A high-speed portable office duplicator, weighing only 30 pounds, has been introduced by a British firm. The hand-operated duplicator can turn out as many as 100 copies a minute. One color can be changed for another in only half a minute. Conventional coated stencils are used, and an automatic paper feeder is said to give "hairline registration."

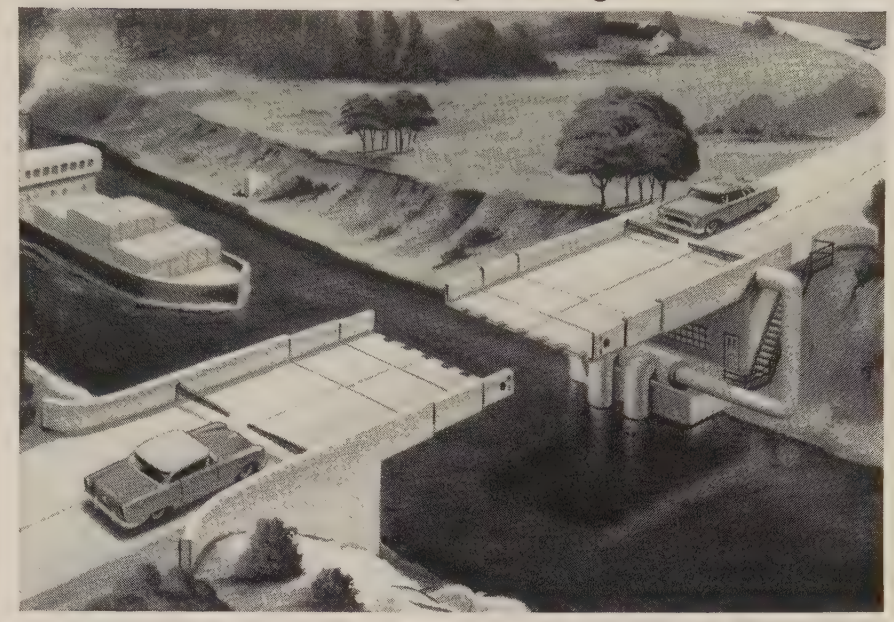
New Twist in Rope

Hawser of polypropylene, a synthetic fiber, has entered a field traditionally belonging to heavy Manila rope. Polypropylene hawser that is seven inches around and weighs one pound per foot has the same strength as Manila rope nine inches in girth and weighing nearly two-and-a-half pounds a foot. The synthetic rope is said to be light enough to float and does not absorb water or freeze like conventional rope.

Steak Meter

A new cooking gadget has been developed that takes the guess work out of broiling steaks. The cook sets a knob on the rheostat device to "rare," "medium," or "well-done," sticks it into the steak, sets the steak to broiling and waits. When the steak is done to the desired turn, a bulb on top of the meter lights up.

MARS outstanding design **SERIES**



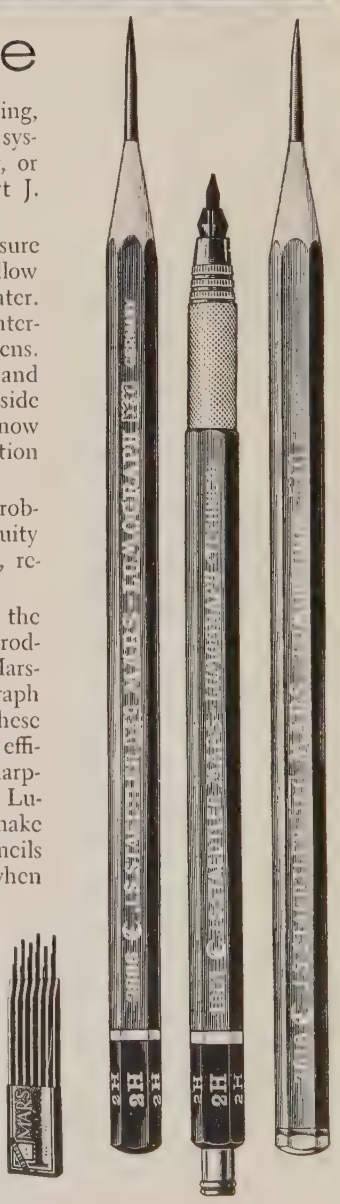
automated bridge

The bridge of tomorrow will be self-activating, equipped with electric-eye controls and an anti-freeze system. No overhead structures will obstruct the view, or interfere with radio reception, according to Robert J. Companik of Chicago.

In his design, the bridge is operated by pressure pumps that draw water from the canal into the hollow structure and hold it shut by the weight of the water. To allow boats to pass, pressure is released, counterweights pull the sections together, and the bridge opens. An electric eye down the canal activates the opening and the bridge does not close until an eye on the other side is passed. Heating units keep both eyes free from snow and ice, and a brine system keeps the bridge in operation in freezing weather.

Many ingenious solutions to traffic and other problems are on the boards today. To make their ingenuity clear, and to translate them from idea into reality, requires the best of drafting tools.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom color-drafting pencil, 24 colors.

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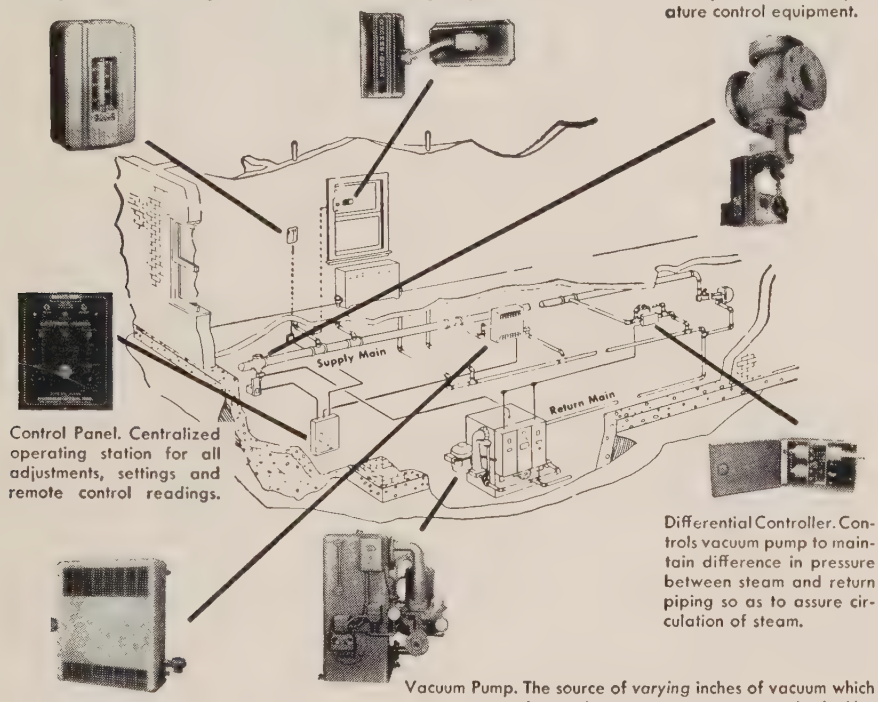
Selector. Determines demand for heat by measuring the effect of outside weather conditions and inside building temperatures.

Control Valve. Regulates admission of steam into heating system, as called for by automatic temperature control equipment.



Control Panel. Centralized operating station for all adjustments, settings and remote control readings.

Differential Controller. Controls vacuum pump to maintain difference in pressure between steam and return piping so as to assure circulation of steam.

Heat Balancer. Measures rate of steam flow to system to balance heat input with heat demand.

Vacuum Pump. The source of *varying* inches of vacuum which assures steam in *varying* temperatures as required. Also produces necessary pressure differential between supply and return piping to assure quick, complete steam circulation and returns condensate from system to boilers.

You'll find Dunham Bush Vari-Vac, a precision temperature control system, in many well known buildings such as the New York City Housing Authority and Rockefeller Center's RCA Building.

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Television Under Water

Closed-circuit television is providin the "eyes" for connecting lengths of 1 foot diameter concrete pipe in th largest, longest, heaviest and deepe pipeline ever assembled underwater.

The pipeline will extend six-and-on half miles to seat at a depth of 200 fee and will carry hygenically treated effl ent from Los Angeles' Hyperion Sew age Treatment Plant.

Pipe sections—measuring 192 feet i length and weighing four tons per linea foot—are lowered from the world' largest Texas Tower-type mobile pla form and joined underwater.

To be sure that these sections ar properly lined up and that mating joint are waterproof, a specially built saddle mounting two television cameras an eight 500-watt spotlights—travels alon the pipe and scans pipe joints.

Cameras are heavily brass coated an utilize water-resistant glass eyes. A third standby camera can be carried be low by a diver.

Monitoring screens, mounted aboar the tower barge, enables inspectors t watch continuously underwater opera tions. Placement of rock ballast, use to backfill under the pipe after it ha been laid on the ocean floor also wil be under the scrutiny of television cam eras.

Pizza Popularity Rises

Pizzas are close to becoming the mos popular American snack. Pizza sale are expected to reach $500 million thi year, with Americans downing abou 50 million pies a week.

Stereo On Wheels

American drivers will soon be rolling along in a cloud of stereophonic sound if an experimental system now being tested works out. The transistorized stereo tape system for cars is about twice the size of a human hand and offers up to 30 minutes of playing time per side.

Rocket Digs Tunnel

Russian technicians say they have de veloped a rocket-type tunneling device that ultimately may be used to lay pipe or cable without digging trenches. The working end of the rocket is fiitted with spray nozzles for liquid fuel and com pressed air. Ignited, the flame is said to burn through any type of ground formation.

Rayon With Bamboo Base

India soon will start producing rayon pulp from bamboo. Until tests by Japan proved bamboo was suitable for rayon use, India had to import 45,000 tons of pulp annually.

FINAGLE'S LAWS[1]

LAWS OF EXPERIMENT

First Law—If anything can go wrong with an experiment or test, it will.

Second Law—Everything goes wrong at one time.

Third Law—Experiments must be reproduceable; they should fail in the same way.

Fourth Law—Build no mechanism simply if a way can be found to make it complex and wonderful.

Fifth Law—No matter how an experiment or test proceeds, someone will believe it happened according to his pet theory.

Corollary One—No matter what the result is, someone will misinterpret it.

Corollary Two—No matter what results are anticipated, someone will be willing to fake them.

LAW OF MATHEMATICS

First Law—In any collection of data, the figures that are obviously correct, beyond all need of checking, contain the errors.

Corollary One—No one whom you ask for help will see the errors.

Corollary Two—Everyone who stops by with unsought advice will see it immediately.

Second Law—If, in any problem, you find yourself doing a transfinite amount of work, the answer can be obtained by inspection.

Corollary One—If inspection fails to yield results, judicious application of one of the methods outlined in the text following may be in order. (See Fingale's constant, etc.).

LAW OF SYSTEMS

When a system becomes completely defined and all avenues of inquiry and expansion are explored, an uninformed, independent, amateur experimenter will discover something which either abolishes the system or expands it beyond recognition.

LAW OF THE LOST INCH

In designing any type of construction, no overall dimension can be totalled correctly after 4:30 p.m. on Friday.

Corollary One—Under the same conditions, if any minor dimensions are given to sixteenth of an inch, they cannot be totalled at all.

Corollary Two—The correct total will become self evident at 8:15 a.m., on Monday.

LAWS OF REVISION

First Law—Information necessitating a change in design will be conveyed to the designer after, and only after, the plans are complete. (Often referred to, as the "Now they tell us" law.)

Corollary One—In simple cases, presenting one obvious right way versus one obvious wrong way, it is often wiser to choose the wrong way so as to expedite subsequent revisions.

Second Law—The more innocuous the modification appears to be, the further its influence will extend and the more plans will have to be re-drawn.

Third Law—If, when completion of the design is immenent, field dimensions are supplied as they are, instead of as they were meant to be, it is always simpler to start all over.

Fourth Law—It is usually impractical to worry beforehand about interference, if you have none, someone will supply some for you (cf. first, second, and third above).

EDITOR'S NOTE: A reading of the laws of Finagle as stated above will show that the compilation is far from complete at this date. Further research is needed, especially in the Law of Systems. Other work needs to be done to correlate Finagles laws with the laws of the Universal Perversity of Matter. Very little is actually known in this latter field, so in an attempt to at least begin the systematization, the known laws will be stated.

LAWS OF THE UNIVERSAL PERVERSITY OF MATTER

First Law—Any mechanical or electrical device is most likely to fail the day after the manufacturer's guarantee expires.

Second Law—Any mechanical or electrical device with any malfunction short of complete breakdown will function perfectly in the presence of any trained serviceman.

Third Law—Matter will be damaged in direct proportion to its value.

Corollary One—If a mechanism is accidentally dropped, it will fall in such a way that the maximum damage will occur.

Corollary Two—Things fall at right angles.

To assist in the research suggested, the following rules have been formulated for the use of those new to this field.

RULES OF EXPERIMENTAL PROCEDURE

1. A record of data is useful, it indicates that you have been busy.

2. To study a subject, first understand it thoroughly.

3. In case of doubt, make it sound convincing.

4. Draw your curves, then plot your data.

5. Do not believe in luck, rely on it.

6. Always leave room when writing a report to add an explanation if it doesn't work. (The rule of the way out).

One of the more recent developments in the field of interpretation of experimental data, which expands the usefulness of the well known Finagle Constant[2] and the more subtle Bougeurre Factor[3], is the Diddle Coefficient.[4] (These items are loosely grouped, in mathematics, under the constant variables, or as some workers prefer, variable constants).

The derivation of these useful concepts are as follows:
Finagles Constant[5] is used as a multiplier of the zero order term:

1. The main body of these laws was formulated during the time Finagle was trying to prove his fundamental discovery that "If a string has one end; then it has another."

2. Finagles Constant may be characterized as changing the universe to fit the equation.

3. The Bougeurre Factor is characterized as changing the equation to fit the universe. Named after Bougeurre, a French professor of mathematics. The more common designation, due to language difficulty, is "bugger."

4. The Diddle Coefficient is characterized as changing things so that the equation and the universe appear to fit without requiring any change in either.

5. Dr. Finagle was, actually, a German by the name of von Nagle, who moved to Ireland where his associates misunderstood the pronunciation of his name.

(Continued on Page 47)

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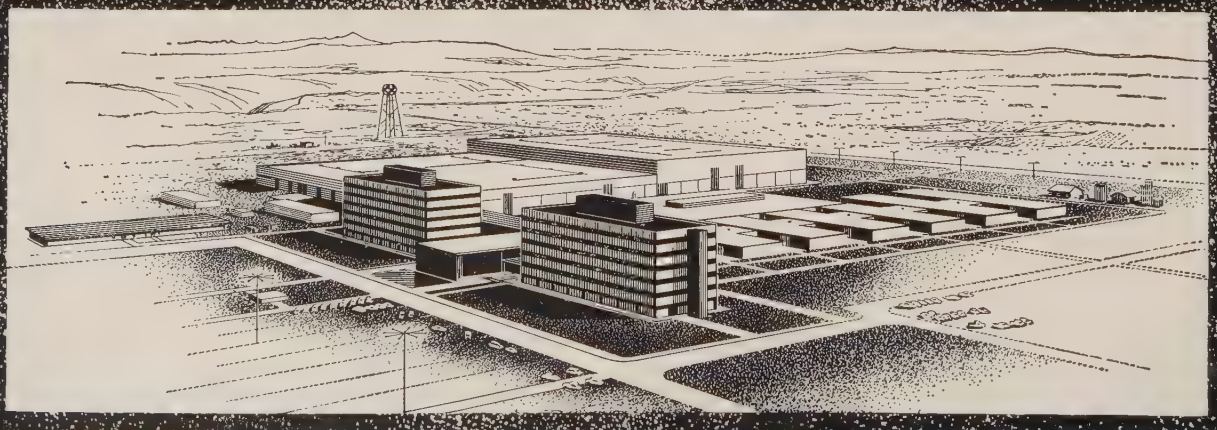

FINAGLE'S LAWS

(Continued from Page 45)

(1) $X' - K_f + X$

where: X = result obtained
X' = result desired
K_f = Finagle's constant

The more subtle Bougeurre factor is used as a multiplier of the linear term:

(2) $X' = K_b X$

where: K_b = the Bougeurre factor

It is very soon recognized that the advantages of both these terms, (1), and (2), could be achieved together if the relation was written in the form:

(3) $X' = K_f + K_b X$

By expanding (3) and using the Diddle coefficient[6] as the multiplier of the quadratic term we obtain:

(4) $X' = K_f + K_b X + K_d^2 X^2$

where: K_d = the Diddle coefficient.

Equation (4) has only recently been accepted. Through its use the bit of experimental data can be improved in most cases by a factor of two.[7]

The original account of Diddle's great discovery will be found in his paper, "On the Significance of Random Experimental Data," (doctorial thesis, Mistakenic University, 1932; also printed in the *Journal of the Association of Philosophical Engineers,* Volume 12, pages 872-898, October, 1932.

An example of the usage of the von Nagle (Finagle) factor is the introduction of the planet Uranus; since Newtonian Laws didn't agree with the observed universe, the planet was introduced into the universe to make the universe fit the equations. It was much later that the planet was actually observed.

The Bougeurre factor is typified by Einstein's work on the basic equations of motion and gravity, leading to the relativity concept, so that the equations were adjusted to fit the observed facts of the orbit of Mercury.

The photographers use of a "soft" focus lense in taking portraits of women over thirty-five represents an excellent example of using the Diddle coefficient. By sufficiently blurring the results, they are made to appear to fit the facts in a more satisfactory manner.

6. Also known as the "soothing" factor, or "Soothing" factor, mathematically somewhat similar to the damping factor; it has the characteristic of dropping the subject under discussion to zero importance.

7. As suggested by Ronald Featherstonehaugh Diddle (B.S.), Flubar College 1928, Phd., Mistakenic University, 1932).

THE ENGINEER

With clouded wits the Engineer sits
And pushes pens and pencils.
While day by day, years slide by
Among his ink and stencils.

He works and works and never shirks
(He couldn't do without it)
And if he stops, asleep he drops
And then he thinks about it.

With head that sinks and frame that shrinks
He does his toilsome duties
Without a glance from gay romance
And blind to all her beauties.

And when at last his life is past,
There comes no time to show it
For Engineers are dead for years
Before they ever know it.

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* *Candidates are selected each Spring for classes starting in September.*

Begged, Borrowed, and . . .

Edited by The Staff

He (in car, to sweet young thing): "Pardon me, but . . . er . . .?"

Sweet young thing: "No, you've never met me before at Palm Beach, Newport, or Atlantic City. I wasn't on the Pullman car or the New York Central last Tuesday. I know I'm good looking and I'm not bashful. I'm not going your way, and I wouldn't ride with you on a bet. I didn't go to school with you; I'm waiting for a streetcar; I don't want a light; and I know plenty of college boys. Furthermore, I have a fiance who weighs 220 pounds. Now, were you going to say something?"

He (still in car): "Yes. You're losing your underwear."

* * *

Do you know the definition of a redhead?—A communist outhouse.

* * *

Bob drove his girl out one mile in the country and said, "Are you a Camel or a Chesterfield girl?"

She said, "How is that?"

"That means do you walk a mile or do you satisfy."

* * *

A golfer leaving a bar,
Gave his parents quite a jar;
He picked up his putter,
Smashed the head of his mutter,
And finished with one over par.

* * *

Give a woman an inch and she becomes a ruler.

* * *

"No," said the centipede, crossing her legs, "a hundred times no."

* * *

"My heart is in the ocean," cried the poet.

"You've gone me one better," said the seasick friend taking a firmer grip on the rail.

* * *

It was homework time at the Ruben home. "Benny," said Mama Ruben, "How many is seven and four?"

"Twelve," replied Benny.

"Not bad for a little shaver," volunteered Papa Ruben, "He only missed it by two."

Coed: "Do you think I'm conceited?"

M.E.: "No, why?"

Coed: "Girls as good looking as I am usually are."

* * *

If all of the automobiles in the world were put end to end, 98% of the drivers would immediately pull out of line to pass the car ahead.

* * *

It was on a deserted street. The hold-up man pointed a gun at a well dressed, good looking girl and commanded "Stick 'em up!"

"You're out of luck," said the girl. "I haven't got a dime."

"Don't give me that stuff," sneered the villian, "anybody as well dressed and good looking as you always has dough."

"I'm not kiddin', Bud!" said the girl.

"I'll find out for myself," said the mean old man, and he started searching her. He felt in her shoes, her hose, looked in her purse, all her pockets, felt in her bosom, and finally, in desperation, he searched her under garments. He found no money.

Stepping back, he said, "Okay, gal—go on. I've never seen anybody as broke as you!"

"That's what I tried to tell you," said the girl, "but I tell you what . . . if you'll frisk me again, I'll write you a check!"

* * *

Lou: "For the life of me, I can't see why you want to marry that roustabout. He's just an everyday sort of man."

Sue: "Shucks, Lou, what more could any girl want in a husband?"

* * *

Personnel Director: "And on this job, you must be determined to show your ability, or bust . . .!

* * *

The secretary said she'd do anything for a fur coat. When she finally got it, she couldn't button it.

* * *

Students are like blotters, they absorb what the instructor says, but they get it backwards.

C.E.: "May I sit nearer?"

Co-ed: "No you'll . . ."

C.E.: "No, I wont."

Co-ed: "Well, then, what's the use?"

* * *

Interviewer: "You ask high wage for a man with no experience."

U. of I. Graduate: "Well sir, it much harder work when you don know anything about it."

* * *

News Flash: A Chem. E. has recently completed work on a process to utilize excess doughnut holes to stuff macaroni.

* * *

Whistler, the famous painter, wa exasperated when he came home on night and found his mother sitting i the middle of the living room floor.

"Ma," he said, "You've gone of your rocker!"

* * *

A sheriff rode up to a group of poke playing guys in a western town, an looked at them from atop his trust steed. One of the players looked up an said, "Care for a little stud?"

"Don't mind if I do," replied th horse.

* * *

C.E.: "I suppose you dance?"

Coed: "Oh, yes, I love to."

C.E.: "Great, that's better tha dancing."

* * *

Did you hear about the two girl who accidentally walked into the men' dormitory?

One fainted, but the other stayed calm, cool and collected.

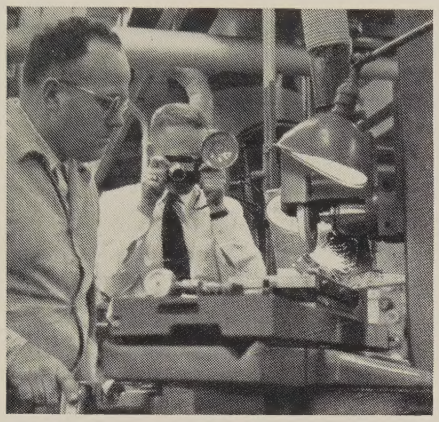
* * *

Mrs. Worthmore and her French poodle were shopping one day, when she noticed the man standing next to her at the counter was looking fearfully at the puppy frisking about his legs.

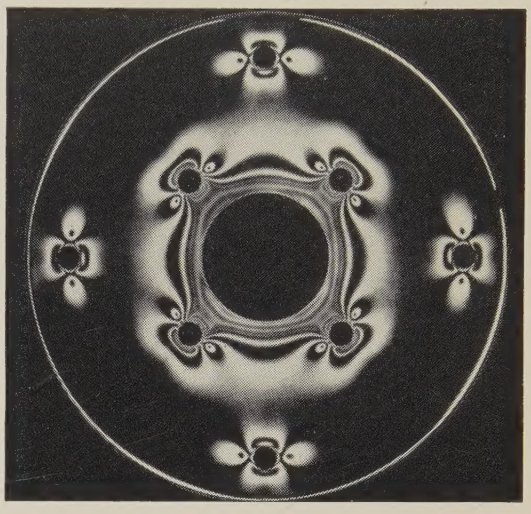
"My, my," she said, "don't be afraid of Felix, he won't bite you."

"Madam," said the man, " I wasn't afraid he'd bite, but I noticed him lifting his hind leg and I thought he was going to kick me."

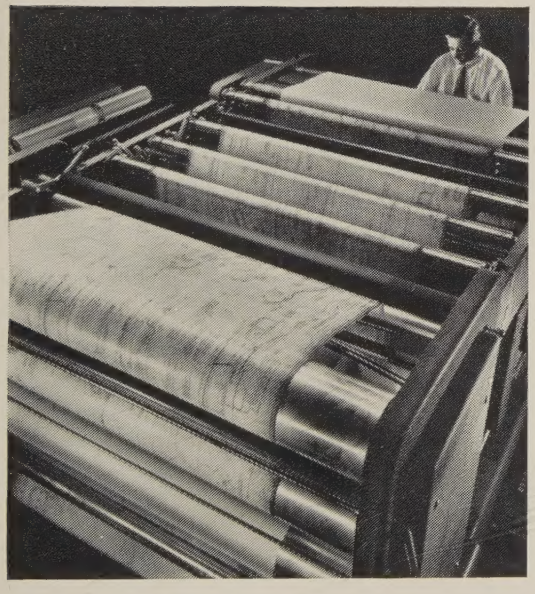
From research to finished product–
Photography works with the engineer



Sparks fly as the plant photographer records a grinding technique for study.



Photoelastic stress analysis helps the design engineer pinpoint areas requiring extra strength.



Giant machines produce a flow of photo-exact engineering drawings—save countless hours of drafting time.

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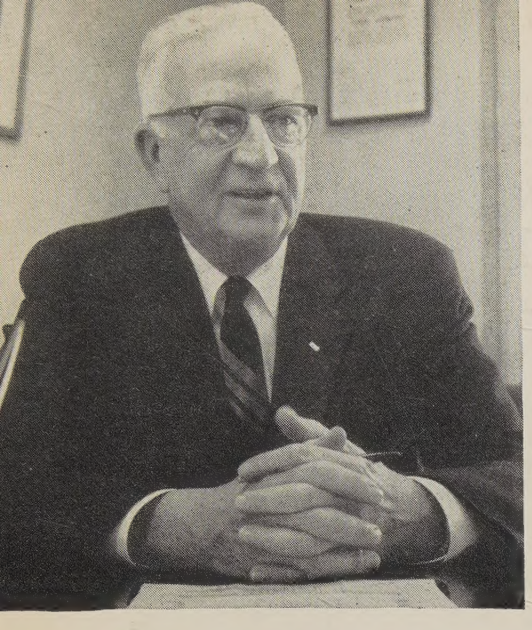

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

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